American Denture Society Meeting. Chicago, Illinois, February 4 and 5, 1955
American Academy of Restorative Dentistry Meeting. Chicago, Illinois, February 5 and 6, 1955

THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 5 JANUARY, 1955 NUMBER 1

UNIVERSITY OF MICHIGAN
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Official Publication of

THE ACADEMY OF DENTURE PROSTHETICS

THE AMERICAN DENTURE SOCIETY

THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

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THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS

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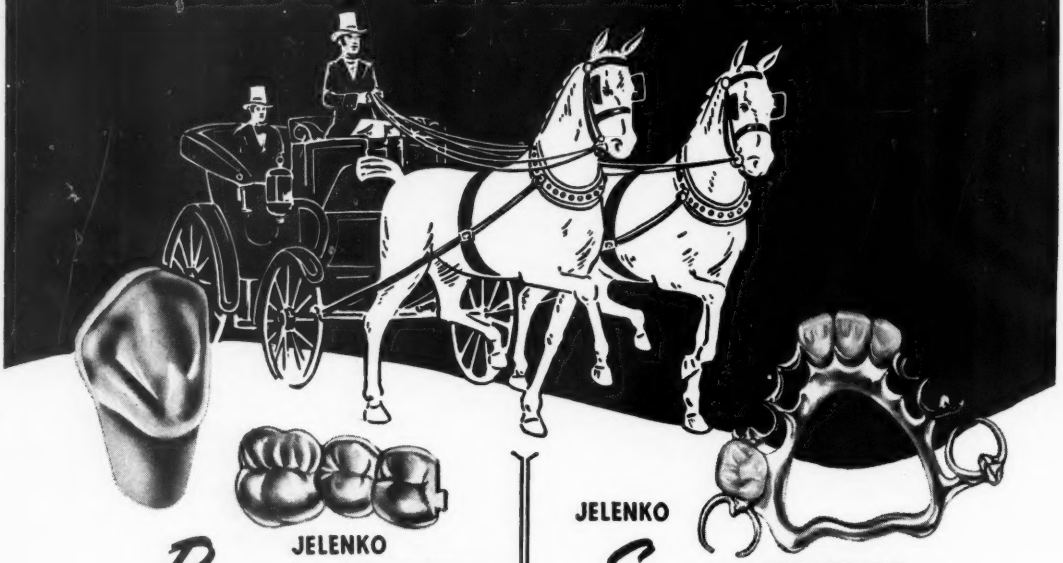

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VOLUME 5

JANUARY-NOVEMBER, 1955

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The Journal of Prosthetic Dentistry

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Vol. 5, No. 1, January, 1955. Journal of Prosthetic Dentistry is published bi-monthly by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription Price: United States and its Possessions per Year $9.00; Canada, $9.50; Foreign, $10.00. Entered as second class matter March 13, 1951 at the Post Office at St. Louis Missouri, under the Act of March 3, 1879. Additional entry authorized at Jefferson City, Missouri. Printed in the U. S. A.

THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 5 January, 1955 No. 1

THROUGH THE EYES OF THE EDITOR

H. A. Young discusses the problems associated with diagnosis for complete dentures. He separates diagnosis itself from a survey of mouth conditions. This approach will provide dentists with a better understanding of the patient and the problems associated with complete denture service than will the usual examination procedures. The orderly sequence of examination and evaluation should prove helpful and enlightening. It will provide information that will emphasize the absurdity of quoting the same fee for all patients needing complete dentures.

Granville C. Fisher discusses some of the psychologic aspects of pain. He points out the biologic utility of pain as being a defense mechanism for the tissues of the body and as an important diagnostic factor. He shows how pain is perceived in the brain while the nerve endings that are sensory to pain are remote. This makes possible the control of pain, in some instances, by the failure or rejection of the stimulation. He presents an interesting hypothesis regarding the acceptance or rejection of pain by patients. If this hypothesis is found to be true, it may explain why some patients complain of pain under dentures without apparent physical damage to the supporting tissues while others with severe damage to these tissues do not complain.

Stanley G. Standard and James B. Lepley discuss the free-way space and its relation to the temporomandibular articulation. They suggest a new definition of centric relation which seems to be inadequate from several standpoints. The key phrase refers to the position of the condyles. The condyles are not visible and are difficult to locate accurately. Certainly, observations must be made at other points on the mandible if a jaw relation is to be established. They are correct when they say that a different horizontal relation of the jaws exists at each level of jaw separation, but this apparent variation in centric relation at different levels is *not* due to protrusive movement of the mandible. It is the result of the spatial relation of the body of the mandible to the condyles which are in a higher plane. They correctly criticize the use of the term *vertical dimension.* This term should always have modifying terms included with it to designate exactly which vertical dimension is being discussed. The discussion of vertical dimension at the level of physiologic rest may be open to question. They point out the dangers of a vertical dimension of occlusion which is too short as well as one which is too great. Their definition of occlusal vertical dimension is worth study. Their interpretation of the anatomy of jaw relations seems to be based upon teleologic reasoning. It is hard to know *what* Nature intends. They say, "the directing force of the muscles of mastication are upward and slightly forward . . . and may create a bend at the neck of the condyle." and, ". . . with the teeth acting as a stop, the pull may be such as to create a bend at the angle of the jaw. . . ." The former might occur, but it seems more logical that this bend would be produced by the pull of the external pterygoid muscles. The latter seems likely to occur only when posterior teeth are missing. The "prognathic movement" referred to is not a movement, but it is a distortion of the mandible which may produce an *appearance* of prognathism. They include an excellent review of methods for determining vertical dimension and describe a method for determining the vertical dimension which is coordinated with centric relation. They conclude from clinical observations that the entire mandible moves from the position of physiologic rest to occlusal contact in an upward vertical direction. This is at variance with the observations of most investigators. The instability of bases on edentulous ridges makes their observations open to question. The roentgenographic evidence does not seem conclusive because of the possible variation

in angulation. Further study of the techniques suggested may cause a modification of the conclusions.

Earle S. Smith describes some teaching aids for assisting students to understand the relationships between the various factors of occlusion. They are simple to construct and are easy to use. They should be helpful to dental teachers.

J. S. McKenzie urges a closer cooperation and a better understanding between the specialties of periodontics and prosthodontics for the improvement of diagnosis and treatment of partially edentulous patients. He points out many things which may be done to save key teeth for patients. If these procedures are properly carried out, many patients may be spared the problems that go with the wearing of complete dentures. Since the maintenance of oral health is the primary concern of both specialties, there should be no resistance to cooperation between them.

Fred N. Harris lists five problems which may be encountered with distal or mesial extension partial dentures and suggests the precision dowel rest attachment as the solution to these problems when it can be used. He describes the technique for making the attachment and tells of its advantages. He cautions that the most accurate accomplishment of the procedures of construction is essential to the success of the attachment. The attachment seems to hold promise as an effective retainer for partial dentures and has the additional advantage of serving as a stress-breaker under certain conditions.

Allison G. James describes a stress-breaker for maxillary partial dentures which combines the advantages of rigidity of the attaching framework and the resilient attachment of the denture base to this framework. The resilient connector in the palate aids the denture base to assume its normal position when occlusal stress is terminated. It seems to be an effective and practical device for the purpose.

Herbert R. Boyd, Jr., reviews the various types of anterior and posterior pontics in current use for fixed partial dentures. He indicates the most favorable situations for the use of each type of pontic and notes their advantages and disadvantages. He suggests that some ingenuity is necessary in producing modifications to meet specific conditions.

A. H. Woolson describes a technique for baking porcelain on gold restorations. The procedure is simple to carry out and is practical for the situations where it is indicated.

P. W. Herrick discusses the importance of maintaining the spaces in the dental arch where deciduous or permanent teeth are lost. He describes a removable appliance which can be used to reopen spaces after the adjoining teeth have drifted. The appliance is simple to construct and can do the job if it is used judiciously.

Ralph W. Phillips and Raymond R. Price report their findings regarding some factors which influence the surface hardness of stone dies which are poured in alginate impressions. This is a timely investigation, but it must be remembered that it covers only one phase of the accuracy of stone dies. They make several recommendations based on their observations. These should prove helpful in handling these materials. The variations in the behavior of the different alginates as they affect the surface of the stone emphasizes the importance of following the manufacturers' directions.

Homer Cree Vaughan reports his observations of the external pterygoid mechanism in a patient with dysfunction of the right external pterygoid muscle. The description of the jaw movements of this patient does shed some light on the function of the external pterygoid muscles. It must be recognized, however, that the temporomandibular joint on the left side was not unaffected by the unnatural displacement of the mandible to the right side, and that conditions observed on the so-called normal side were modified by this unnatural jaw position. We wonder if there was sufficient evidence for some of the positive statements which were made. Can we be *sure* that it was a bone to bone contact that stopped the posterior displacement of the affected condyle? Could it be the temporomandibular ligament that stops the posterior displacement? Certainly the neuromuscular system plays an important role in the positions assumed by the jaw. Certainly the normal external pterygoid muscle exerts a continuous pull in a forward and medial direction. The normal tonic contraction would do this. The lack of tonic contraction on the affected side would permit the tonic contraction of the muscles which retract the mandible to pull the condyle to a more posterior position than otherwise. It is important to note that the neuromuscular system can alter the positions of the condyles according to the way in

which it is stimulated. The statement that the temporomandibular joint is a "flexible" joint does not seem to be supported by sufficient evidence.

Thure Brandrup-Wognsen suggests that roentgenograms of temporomandibular joints be made from an angle 15° above and 15° behind the joint. This is done to place the central ray parallel to the long axis of the condyle. He has examined various methods and has found them to be unsatisfactory for different reasons. He describes some comparatively simple equipment for positioning the head and the x-ray tube. The technique for its use is easy, and it seems to produce excellent results.

Joseph S. Landa suggests that the terms glenoid cavity, glenoid fossa, and temporomandibular joint be replaced by more accurate and descriptive terms. While a change may be indicated, it seems unfortunate that the terms he suggests are so cumbersome. Usage should be considered before these terms are discarded.

Howard J. Merkeley describes the accessary muscles of mastication on the lingual side of the mandible, and shows the relative positions of the tongue under various tongue actions. These anatomic relations are then correlated with the form of a lower denture. This seems to be a sound method for devising an adequate lower impression technique.

R. T. Hill discusses anatomy of interest to the prosthodontist. He explains the changes in anatomic relations which result from the resorption of the residual ridge. He points out the importance of the consideration for the tensor veli palatini muscle in the design of an upper denture, and the displacement of the condyle which results from too short a vertical dimension. He cites this displacement as being the cause of some referred pain in the tongue.

Edwin H. Smith, Jr., discusses the prosthetic treatment of maxillofacial injuries. The large number of automobile accidents which cause maxillofacial injuries makes this subject of interest to civilian dentists as well as to military dentists. The same principles apply, and similar treatment must be followed. It is properly emphasized that the prosthetic treatment of these patients is of equal importance to the services of other specialists in the care of these patients. Cooperation between the members of the "team" caring for these patients is essential, and a mutual understanding of the problems of the other members of the "team" is necessary. A review of the various types of splints, together with their advantages and disadvantages and indications, is given. The appliances described are ingenious, and they may be modified to meet the requirements of specific situations. The techniques for making some of the appliances are described.

Jerome C. Strain describes a three dimensional pantograph for use in facial prosthesis. A mirror image of a cast of the part on one side is produced by means of this instrument so the restoration will duplicate the part on the opposite side of the face. It is a relatively simple instrument which will be of great assistance in this work.

John P. Knowlton discusses the factors involved in maxillary implant dentures, and the means for avoiding difficulties in their construction. The statement that certain patients can be treated satisfactorily *only* by maxillary implant dentures is open to question. He correctly points out the close relation between bone resorption and the poor systemic condition of some patients, but it seems that a continuing poor systemic condition would continue to affect the bone even after an implant denture was inserted. He suggests proper load distribution as an important factor in the design of the implant substructure. If pressure causes the resorption, one might ask if an implant denture would produce more of it than a soft-tissue-borne denture, when the possible maximum pressures are greater with the implant dentures. Wide distribution of occlusal forces is a sound principle with either type of denture. The use of a very rigid substructure seems to be indicated for the proper distribution of occlusal forces, and there can be little question of the proper placement of the abutments. The emphasis placed upon the occlusion of the superstructure indicates that implant dentures are subject to the same requirements of exactness as soft-tissue-borne dentures. In reality, both are supported by the same bones, and both may fail on account of changes in these supporting bones.

Charles Schroeter supplies the answer to the question of effective apperture in dental photography. The many unusual situations in which dental photography is done require techniques which are not common knowledge. One of these problems is solved in this article.

—Carl O. Boucher

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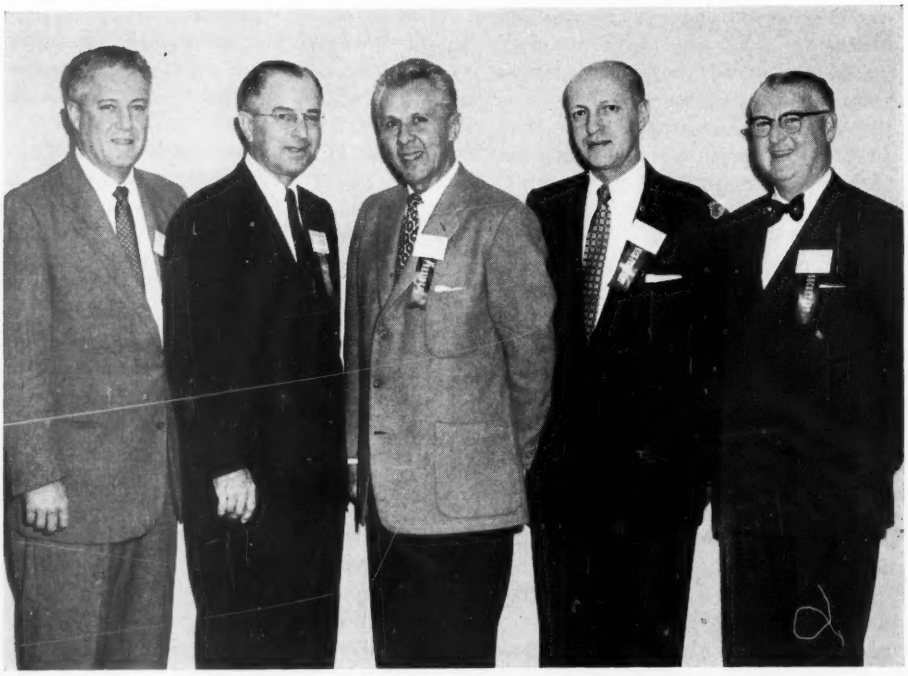

The officers of the American Denture Society at the 26th annual meeting at the di Lido Hotel in Miami Beach, Fla., November 5 and 6, 1954. In the center is Dr. Victor L. Steffel, Columbus, Ohio, President, with the new officers who assumed their duties at this meeting. Left to right—Dr. Fred N. Harris, Pasadena, Calif., Vice President; Dr. Cecil H. Bliss, Sioux City, Iowa, President; Dr. Steffel; Dr. Samuel Cohen, Cleveland, Ohio, President-Elect; and Dr. Arthur L. Roberts, Aurora, Ill., Secretary-Treasurer.

DIAGNOSTIC SURVEY OF EDENTULOUS PATIENTS

H. A. YOUNG, D.D.S.*

School of Dentistry, University of Washington, Seattle, Wash.

THE CREATION of a proper denture prosthesis for an edentulous patient has always been a difficult achievement for dentists. Difficulties are created by the very extensive loss in spatial dimensions of the orofacial area, by alterations and deteriorations in the biophysical conditions of the anatomic parts, and by similar changes in the interdependent functions and functional relations of the edentulous masticatory organ. Psychologic-esthetic problems are created by the public's and the patient's sensitivity toward aging and appearance deficiencies manifested in the orofacial region especially of edentulous patients. Dentists have been slow to recognize and evaluate troublesome factors commonly associated with edentulous patients. They have not recognized the great variation in the environmental background problems of edentulous patients and the importance and effect this factor has on the patient's esthetic and functional needs and upon the mental attitude of the patient toward artificial dentures. Difficulties are created by the dentist's failure to formulate a treatment plan before treament is initiated, and by the difference in viewpoint of dentists and patients on the responsibility for success in treatment.

The realization that problems do exist and that a wide range of obstacle factors must be identified, evaluated, and overcome to create a prosthesis which will meet the objectives of treatment has come about partially by the attempts to determine the relative responsibility between the dentist and the patient for success in treatment, and partially by the dentist's attempts to determine how success can be attained irrespective of responsibility. The recognition and evaluation of obstacle-problem items have been achieved by the slow empiric clinical process which has enjoyed intermittent periodic application throughout the past century, yet has been significantly accelerated during the last quarter century.

Willard[1] early in the 1850's and Atkins[2] and Beers[3] in the early 1860's called attention to the detrimental influence on denture comfort and usefulness of irregular bony ridges, such as projecting interceptal bony points, and of denture mobility due to an excess of resiliency of the mucosal covering of residual alveolar ridges. From this early beginning, and focusing of attention on oral conditions, many other dentists have contributed additional items and interpretive evaluations of item influence on prosthesis qualities and treatment success.

Read before Dental Staff, Seattle District Office, Veterans Bureau.
Received for publication March 27, 1954.
*Professor and Executive Officer, Prosthodontic Department.

Dr. House[4] has perhaps been foremost in presenting a routine of executing an endentulous diagnostic survey, in listing the items concerned, and in correlating and interpreting item influence on required denture qualities and patient use of a prosthesis. House stated, "The variability of biologic factors in each case presenting for denture service predetermines the procedures, treatment plan, and the prognosis. The art of diagnosis is fundamental to the health of the patient and to the success of the practitioner."[5] He recommended that a diagnosis be made for every patient before the dentist contracts to render a complete denture treatment. This recommendation has become a somewhat standard practice, yet inefficiently executed. The items involved, the interpretation of their influence and importance, and the execution and routinization of this step have been modified to meet the greater knowledge accruing from its usage since the early 1920's.

Webster[6] defines diagnosis as "the art or act of recognizing and classifying diseases by symptoms." Few diseases were recognized a quarter century ago as being associated with edentulous oral structures or functions; hence this phase was considered of minor importance. Today it is realized that systemic diseases,[7] as well as local oral diseases, do influence treatment results and that they are manifested to varying degrees in the oral tissues of the denture area or in the functions of the masticatory organ and its associated organs. This diagnostic phase does not seem today to be as productive of difficulties as does the correlated biophysical phase. No doubt dentists are somewhat unprepared to execute this phase and are somewhat reluctant and fearful of invading the physicians' sphere. The diagnostic phase merits increased application on the part of the prosthodontist, and eventually it will earn its proper importance, and will yield added ease and success in treatment. It is doubtful if this phase will influence denture physical qualities to the same extent that it will influence mouth preparation and patient education.

Associated with the edentulous state are certain modifications in physical characteristics of the residual arches and associated tissues which exert a tremendous influence on treatment plan and end results. The detection and evaluation of these items does not fall properly within the interpretation of the term "diagnosis." The term "survey" does denote and connote the series of investigative actions of itemizing and evaluating the variations in the physical size, form, and surface characteristics of the arch, the resiliency of mucosal support tissue, the potentials of physical and functional stresses and torques, the distribution of stress to support tissues, and the potential of prosthesis mobility and of obtaining acceptable material mass and appliance form.

The term "survey" is used by engineers to indicate essentially the same function as we associate with it. Webster[8] defines survey as: "To look over or examine with reference to condition, situation, and value; to ascertain the state of, to inspect, to determine the form, extent, position, and etc.; to grade or measure." To examine visually, digitally, or instrumentally, to determine the physical qualities, and to grade or measure oral conditions and anatomic components are exactly the major functions of the present-day survey phase of an edentulous diagnostic survey routine.

Operative dentistry and other dental restorative and treatment fields have realized the need for an examining chart which records graphically, or by numerical letter designations, the existing physical state or stage of dental and oral tissue damage, destruction, malformation, or malrelations caused by injury, disease attacks, actions of physical and chemical forces associated with use of organ and/or remedial and restorative restorations. These charts have different forms, included items, and associated examining procedures; therefore, each possess varying objectives and values which are important to the dental field for which it was designed.

All fields of dentistry have these common needs for a chart record: to aid in defending a law suit for damages or for malpractice, to check the adequacy and appropriateness of treatment procedures and business methods employed, to record the conditions present in the mouth or of the patient in general, to establish a treatment plan, and to record other business and professional items of importance. Prosthodontics has no lesser need for a chart record similarly associated with the examining (diagnostic survey) step, and such should be used by all practicing dentists.[9] Teachers find such a procedure and record an excellent vehicle for alerting the student to the many factors and conditions bearing on successful denture treatment. It would seem that the reference to the several items of a prosthodontic diagnosis survey would cause the general practitioner better to recognize and evaluate these troublesome conditions and would make him more efficient in spotting difficult or failure cases.

To execute a diagnostic survey properly requires knowledge, skill, and experience in the biologic and physical sciences and in certain ranges of the fields of pure arts and socioeconomics.

The objectives of an edentulous diagnostic survey may be listed as follows:

1. To detect, identify, and evaluate diseases common to the edentulous oral structures and to the edentulous condition.
2. To detect, identify, and evaluate oral manifestations of systemic diseases.
3. To detect and evaluate disturbances in function of the masticatory organ or its components.
4. To determine the variations in the anatomicophysical characteristics of an edentulous mouth.
5. To evaluate the difficulties associated with the variations in the anatomicophysical characteristics of an edentulous mouth in relation to treatment procedures, and their bearing on the end results.
6. To determine the patient's relative business, social, and other demands on denture qualities and values.
7. To evaluate the patient's need for, and the relative difficulties of creating good denture and facial esthetics.
8. To determine the need and type of auxiliary treatments preparatory for denture treatments, i.e., surgical, medical, or psychiatric.
9. To ascertain the mental attitude and potential of cooperation to be received from the patient during treatment and subsequent use of the dentures.

10. To discover other pertinent conditions and values revealed only through executing a diagnostic survey procedure.
11. To determine the skill, experience, and time required to complete the treatment successfully.
12. To develop a rational treatment plan.
13. To sum up and inform the patient of the difficulties associated with the case.
14. To make possible a prognosis for the patient.
15. To arrive at a just and satisfactory fee.
16. To procure a chart record of the data relating to the patient.

To meet these objectives, there is need for a logical and practical routine, a suitable record form, the inclusion of items of basic and general value, and an execution time that is not excessive. The value of any such routine is limited by the knowledge and discriminating ability of the dentist and by his willingness to devote the time required to identify and evaluate all pertinent data relating to the case.

DIAGNOSTIC SURVEY DATA

Some dentists have evolved an elaborate record which is time-consuming to execute; consequently they charge a fee for this service which is independent of the regular treatment fee. Such a record includes many of the items to be discussed, and the routine includes: the making of primary impressions and the casts, the establishing of a vertical dimension, the mounting of the casts in an adjustable articulator, and the setting of the articulator controls by a check-bite, the taking of radiographs and facial mask impression and casting the model, the examining of oral structures, and the securing of a financial rating. Such is an extensive procedure which is more likely to be short-circuited or done at the dentist's leisure without adequate patient reference, and so would seem to lose much of its value. Such a routine seems more of a promotion scheme than an honest effort to gather pertinent data about the patient.

DeVan[10] has stated, "The dentist should meet the mind of the patient before he meets the mouth of the patient. The patient should be given the opportunity to tell the dentist what he wants before the dentist tells him what he needs."

The first item, therefore, in reference to methods and procedures of acquiring the data is to encourage the patient to talk of his needs as he sees them, thus revealing his knowledge of denture qualities required or attainable, his idea of the ease in which denture use is acquired by the patient, and his conception of the responsibility for success. The use of leading questions and answers is a good means to stimulate patients to disclose the information desired by the dentist which enables him to detect and correct misconceptions of artificial dentures.

Additional procedures in executing this step are as follows:

1. Observe all the functional acts of the patient, such as walking gait, posture, speech, breathing, hand manipulations, lip and jaw movements, etc., without the patient's being conscious of the dentist's scrutiny.

2. Visually examine oral and facial structures as to normality in form, dimensions, and orientation in the face space.
3. Digitally examine oral structures and surfaces as to normality in form, size, surface smoothness, and contour.
4. Analyze roentgenograms for values revealed only by this means, such as foreign bodies, retained roots and teeth, architectural bone form, bone mineralization, and soft-tissue thickness.
5. Consult physicians or biologic laboratory tests when necessary.
6. Consult psychotherapists when necessary.
7. Execute a definite prescribed routine of checking selected items, the validity and worth of which have been proved.
8. Make out a chart record of conditions which indicates the presence or absence, the relative severity of form, and the relative difficulty of included items.
9. Analyze data obtained and inform the patient of the specific problems and difficulties relating to his case.
10. Establish a treatment plan.
11. Quote a fee and inform the patient of other business details.

The factor items of a diagnostic survey are generally listed under the main headings of anatomic, physiologic, physical, economic, and social. The item headings adopted should be those which actually have an important bearing on the phases of denture treatment. The sequence of evaluating the items should bear a near relation to the natural sequence of observation or recognition of the items. The rating scale should be a simple one of few grades, and preferably one which indicates readily the relative degree of difficulty associated with any one item. Such a rating scale as the following is acceptable: 1 for the best or least troublesome condition, 2 for an average condition, and 3 for the poorest or most troublesome condition. A similar rating scale is acceptable to indicate the relative presence of certain physical forms or conditions, such as, 1 for a square-type ridge form, 2 for a tapering-type ridge, and 3 for an ovoid-type ridge form. Such a combination rating scale favors a universal recognition of factor values for professional discussions which would not require wordy discussions to indicate a factor, condition, or quality.

INTERPRETATION OF DATA

At the University of Washington, we have adopted the following factor or item headings: general factors, denture history, facial characteristics, oral physical characteristics, and physiologic characteristics and habits. The afore-mentioned rating scale is also used, yet some higher numbers are used when necessary to indicate certain physical values.

The items under the heading of "General Factors," are sex, occupation, nationality, and menopausal influence. A brief interpretation of the factor items will be given, for this article would be incomplete without it.

EDENTULOUS DIAGNOSTIC SURVEY

CLINIC CHART

Patient_____ Reg. No._____ Date_____ Student_____

Rate relative difficulty of item in right hand column

NO.	ITEM	CHARACTERISTICS	RATING 1	2	3
1.	GENERAL FACTORS				
	A. Age	Chronological_____ Biological_____			
	B. Sex	Male_____ Female_____			
	C. Occupation	Employed_____ Unemployed_____			
	D. Nationality	_____			
	E. Menopausal Infl.	Pre._____ Active_____ Post_____			
2.	DENTURE EXPERIENCE	Vet._____ Exper._____ Beginner_____			
3.	FACIAL CHARACTERISTICS				
	A. Typal Form	Sq._____ Taper_____ Ovoid_____ Mixed_____			
	B. Symmetry	Symmetric_____ Sl. Asymmetric_____ Marked Asymmetric_____			
	C. Profile	Straight_____ Concave_____ Convex_____			
	D. Aging-Collapse	None_____ Slight_____ Marked_____			
	E. Lip Action	Norm._____ Sl. Atyp._____ Mkd. Atyp._____			
	F. Tissue Tone	Hypotonic_____ Norm._____ Hypertonic_____			
4.	ORAL CHARACTERISTICS				
	A. Arch Form	Square_____ Taper_____ Ovoid_____			
	B. Arch Size	Small_____ Medium_____ Large_____			
	C. Residual Ridges				
	Surface Form	Smooth-Irreg.: Sl._____ Mkd._____			
	Frontal Cross Section	Sq._____ Taper_____ Ovoid_____ Flat_____			
	Relationship	Norm._____ Orthognath._____ Prognath._____			
	Mucosa				
	Thickness	Medium_____ Thin_____ Thick_____			
	Color	Pale Pink_____ Pink_____ Red_____			
	Pathology	None_____ Treatable_____ Surgerized_____			
	Border-Muscle Attach.	Close_____ Average_____ Distant_____			
	Resorption	Average_____ Deficient_____ Excess_____			
	D. Vault Form	Square_____ Taper_____ Ovoid_____ Flat_____			
	E. Tori	None_____ Slight_____ Marked_____			
	F. Denture Space	Average_____ Deficient_____ Excessive_____			
	G. Tongue				
	Size	Small_____ Medium_____ Large_____			
	Activity	Inactive_____ Active_____ Atypical_____			

EDENTULOUS DIAGNOSTIC SURVEY—CONT'D

CLINIC CHART

Patient_____ Reg. No._____ Date_____ Student_____

Rate relative difficulty of item in right hand column

NO.	ITEM	CHARACTERISTICS	RATING 1	2	3
5.	PHYSIOLOGIC CHARACTERISTICS				
	A. Muscle Tone	Norm.___ Hypotonic: Sl.___ Mkd.___			
	B. Saliva				
	Quantity	Slight___ Moderate___ Excess.___			
	Quality	Normal___ Thin___ Thick___			
	C. Bruxomania	None___ Sl. Manif. ___ Mkd. Manif.___			
	D. Bone Repair	Healed___ Progressing___ Fresh___			
	E. Vomiturition	Norm.___ Sensitive: Hypo___ Hyper___			
	F. Mental Attitude	Coop.___ Critical___ Indiff.___			
	G. Systemic Involvement	None___ Slight___ Hopeless___			
6.	RADIOGRAPHIC DISCLOSURES				
	A. Bone				
	Cortex	Thick___ Average___ None___			
	Matrix	Small___ Medium___ Large___			
	Mineralization	Norm.___ Calcimic: Hypo___ Hyper___			
	B. Foreign Bodies	None___ Dormant___ Remove___			
	C. Pathology	None___ Present___			
7.	REMARKS:				
8.	PROGNOSIS:				

STUDENT _____

INSTRUCTOR _____

Form suggested by K. C. Downing, D.D.S.

The importance attached to age is that it gives an indication of the patient's ability to wear and use dentures. Two conditions determine this value: (1) the adaptability, and (2) the health and functional state of the patient.

The importance attached to sex is the difference in the esthetic, background, and mental attitude problems. The problems associated with the female sex are usually the more troublesome of the two.

The importance attached to occupation is that each type of occupation presents some special problem relating to denture treatment or use. Unemployment or gratis employment offers problems, and the relative difficulty is variable and peculiar to each; thus it is necessary to analyze and evaluate this factor, or the operator will be hard pressed to think up a suitable alibi.

The importance attached to nationality is that the speech and food habits and the developmental forms offer difficulties in construction and patient use of the dentures.

The importance attached to denture history is that experience does not necessarily indicate a well-informed and reasonable approach to the problems and difficulties of making and using dentures; neither does inexperience indicate a willingness to accept dentist advice or instruction. Each must be examined and evaluated.

The items included under the general heading of "Facial Characteristics" are the face typal form; proportions; symmetry; profile; age and strength; the mouth size and prominence; the lip size, curvature, and interrelationship, and facial tissue tone. These items encompass the physical and functional problems to be encountered and yet relate mostly to the esthetic difficulties.

The items included under the general heading of "Oral Characteristics" are the outline form, size, and interrelationship of the arches; the surface form, cross-sectional form, and relative resorption of the residual alveolar ridges; the ridge mucosal condition; the height of border tissue attachment; the vault form and tori prominence; the denture space available, and the tongue characteristics. The importance attached to these items is that they reveal the physical and mechanical problems associated with tooth arrangement, the problems of stress control, and the problems relating to negative relief.

The items included under the general heading of "Physiologic Characteristics" are muscle and tissue tone, saliva quantity and quality, bone repair, vomiturition, bruxomania, mental attitude, and systemic involvements. The importance attached to these items is that an evaluation of the biologic and physiologic condition of the organ is obtained which indicates the reactions that might be expected from denture use. The evaluation of the mental attitude is an important item which indicates the trouble to be expected from patient ideas and noncooperation.

The items included under the general heading of "Radiographic Disclosures" are the architectural form of the alveolar bone, the character of the ridge cortical plate, the state of mineralization of the bony ridge, the presence of foreign bodies and residual pathologies, the thickness of mucosal tissues, and the nearness of the antral floor to the ridge surface.

SUMMARY

It is readily apparent that the great variability in edentulous mouths, in patients, and in patient backgrounds does present many problem factors in denture treatments. It is equally apparent that the need for knowledge, skill, and experience correspondingly vary with the case, and that in some instances the operator possesses a marked deficiency. The operator who does not recognize this personal deficiency will later sacrifice some of his professional reputation on the altar of ignorance and faulty procedure.

The examining routine is, therefore, a double-edged procedure of evaluating the problems to be met and the possession of the abilities to successfully cope with them. This procedure is a protection to both parties concerned. It takes courage and a high degree of integrity to admit one is unequal to the need, and thus refer the patient to an operator who is more qualified.

The needed "know how" to treat difficult cases successfully is gained only through experience, for schools can give only a limited clinical training and try to indoctrinate an acceptable over-all procedure routine. Private practice calls for an ability to handle correctly the many small variations in form, condition, habit patterns, and human reactions to denture substitutes. LaDue[11] feels that success resides more in this ability to note and compensate for the many small variations than in the strict application of a learned basic routine. There is no one other step in a denture treatment routine which better focuses the operator's attention on normal conditions and their slight variations than this diagnostic survey step. It is difficult to reason why dentists so neglect this one most important step in a denture treatment routine.

There seems no logical reason why the same fee should apply for all denture patients, for the conditions create variable demands on the operator and make each denture an individualized substitute of great value to an edentulous patient. Artificial dentures are perhaps of greater value than other substitutes for human parts if one considers their special abilities to impart a quality of aliveness and beauty, in addition to their remedial and restorative qualities. The editorial by C. N. Johnson[12] excellently projects these qualities of artificial dentures, and it is recommended to all dentists for reading.

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UNIVERSITY OF WASHINGTON SCHOOL OF DENTISTRY
SEATTLE, WASH.

QUICK AND EASY TEMPORARY REPAIR

The brush-on technique can be used to replace the missing portion of a broken tooth in a denture with plastic filling material. Extend the filling to the denture base for retention whenever possible. This is a temporary repair that is quickly done and has a pleasing esthetic effect. It sometimes lasts longer than expected. —*L. O. Edgar*

SOME PSYCHOLOGICAL ASPECTS OF PAIN

GRANVILLE C. FISHER, PH.B., M.A., B.D., PH.D.*

University of Miami, Coral Gables, Fla.

THE CONTROL AND elimination of pain are a continuing concern of mankind. From the first crude efforts of the medicine man in primitive societies, to the multimillion dollar annual business in pain killers today, man has sought to discover relief from the tortures of mind and body.

It was a great benediction to the human race when Dr. Morton, a dentist, administered ether for a surgical operation at the Massachusetts General Hospital in Boston in 1846, discovering the effectiveness of drugs as an anesthetic. Prior to this, however, anesthesia had been successfully produced—not by drugs, but by hypnotic suggestion. In 1842, Dr. Ward in England amputated a thigh, using hypnotic suggestion (then called mesmerism) as an anesthetic. The patient claimed to have felt no pain. In 1845 Dr. James Esdaile performed his first operation on a patient who had been anesthetized by hypnosis. Before he left India, where this operation had been performed, he had used this technique successfully in thousands of cases, about three hundred being major operations, with nineteen of these being amputations. Esdaile maintained that his patients showed no physiologic indications of pain, such as pulse changes and dilatation of pupils, which are normally present. The literature is replete with similar cases, including just about every type of major surgery. The successful use of hypnosis in painless childbirth is a commonplace today. There is a much wider use of hypnosis in medical and dental practice today than is generally recognized.

The use of hypnosis in medicine and dentistry, however, involves a professional risk, due to the lack of acceptance or understanding on the part of the general public. This is especially true in the United States where hypnotism has been associated with quackery, the vaudeville stage, and supernaturalism. For the present at least, we need to discover a nonhypnotic technique for the control of pain where drugs are contraindicated.

This article, however, has a broader perspective than just the practical utility of a technique. We wish here to propose and develop an hypothesis as to the psychologic basis of the experience of pain. With this in mind, we may begin by examining the nature of pain.

UTILITY OF PAIN

Pain has biologic utility and survival value. Complete freedom from pain would be catastrophic to the human being. There are cases of medical record where the pain sense has been absent, with consequences inimical to the well-

*Professor and Chairman, Department of Psychology.

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 13, 1954.
Received for publication June 21, 1954.

being of the person involved. One such case is that of a girl born without sensitivity to the usual pain stimuli. As a result she chewed off the end of her tongue, apparently because it tasted good. When going barefoot, she would cut her feet on broken glass and puncture them by nails, oblivious to any discomfort. The danger of serious tissue destruction and infection is obvious.

Again, pain is essential, very often, for accurate diagnosis. Without the patient's report of the location and the type of pain, the physician would in many cases be unable to treat effectively, with resultant damage and even death to the patient.

Pain is a message carried over the nervous system to the brain, warning of danger or damage, or calling for attention. Hunger pangs are relieved by food in the stomach, which food in turn makes possible the continued survival of the organism. When too much food is taken in, pain again occurs to warn against continued ingestion and possible fatal congestion of the gastrointestinal tract. A broken bone, or a sprained ligament, through the message of pain, can bring about sufficient disuse to allow for mending.

It should be noted, however, that not all nerves carry the message of pain. The brain itself, which is all nerve tissue, can be cut without any sensation of pain. We find that there are specialized nerve fibers, free nerve endings, which initiate the sensation of pain. These free nerve endings are not evenly distributed over the surface of the body or through the deep regions and organs of the body. In other words, some areas of the body are more painful than others, and in these more painful areas are found a greater number of the free nerve endings than in the less painful areas. It should be especially noted that the musculature surrounding the blood vessels is well supplied with these free nerve endings.

One of the properties of protoplasm is irritability; that is to say, protoplasm will respond with agitated movement in correspondence with the intensity of the stimulus. This is the prototype of the effort on the part of complex animal organisms, made up as they are of living protoplasm, to remove themselves from danger. In highly complex organisms such as the human being, the number of individual cells is so great and the protoplasm so specialized that irreparable damage could be done were there not some central control and some system of communication so that a disturbance in a given area could be transmitted to the controlling center and, through the agency of that center, other parts of the organism be brought into cooperative action to remove the noxious or threatening stimulus. Such a central control is the brain and such a system of communication is the vast network of neurons that connect all areas of the body with the brain. Pain, then, is really the perception by the person or organism of the message that has reached the brain concerning a disturbance in some part of the organism that could do or is doing it damage.

CENTER OF PAIN

This would indicate that the pain is not actually in the area that is being damaged or unduly stimulated, but is really in the pain center of the brain.

If this is true, then should the transmitting neural fibers between the source of irritation and the brain be broken, damaged by disease, the synapses spread so that excitation could not "jump the gap" from one neuron to the other, or rendered inactive by a drug, we would not expect the person to experience any pain. And this is just what does happen. In other words, if the nerve impulse does not reach the brain, there is no experience of pain, no matter how much tissue destruction takes place in a given area. Conversely, if the above is true, should the specific area of the brain associated with the pain fibers of a given body area be stimulated, pain should be experienced as though in that body area, even though there is no stimulation in the body area at all. A good illustration of this is the amputee who will experience cramps or severe pain in his left foot even though his left leg has been removed at the knee. The explanation here is that the neural fibers originally extending from the left foot up the entire limb, into the spinal cord, have not been eliminated entirely, but they too have been severed at the knee. The ends of these fibers at the knee sometimes become irritated; and once adequately stimulated, they will propagate that excitation along the remaining portion, and thence on to the pain center in the brain, where the impulses will be perceived as *pain in the left foot.* The pain is not in the irritated body area, but is the perception of the neural message from that area as this is received by the brain.

Sometimes the message reaches the brain but is not perceived or recognized. If the individual is so intensely attentive to something else or if he is distracted, he may not be aware of the neural message even though it is there. I once examined a man who, driving his car with his arm resting on the window, had this arm sheered off when a passing truck sideswiped him but was not aware that his arm was missing until he got out to examine the damage to his own car. The suddenness, excitement, and intensity of the experience in its grosser aspects was such that he perceived none of the impulses reaching the pain center in the brain from the free nerve endings in the arm.

Sometimes there is recognition of many messages that most of us ordinarily overlook because of our attention to other things around us; or, to be more specific, attention to the messages coming into the brain from other sense receptors. The hypochondriac, for example, experiences many pains and discomforts due to an overattentiveness to impulses from the free nerve endings, and a lack of attention to messages from the other senses. This attentiveness and expectancy actually facilitate the passage of such impulses across the synaptic junctions. We perceive more readily that which we are "set" to perceive.

Now I must indulge in a personal reference. This problem of pain has interested me for some years. I have experimented upon others and upon myself in an effort to find some answers. Having had a good bit of dental work done, I have utilized these experiences for experimental purposes. A great portion of this work, including Class V fillings and gold-foil fillings, has been carried out without drug anesthesia. I am aware that a number of persons refuse Novocain, preferring to endure the pain than to have the drug. Enduring pain, however,

is quite different from not perceiving the pain in the beginning. For example, I understand that gold-foil fillings, although better, are avoided because very few patients can tolerate the "trip hammer." My dentist in Miami put two of these in for me at one sitting, and I went sound asleep even as the pounding was taking place.

ACCEPTANCE OR REJECTION OF PAIN

This leads me to my hypothesis, which is: *When the person emotionally rejects a situation or stimulus, but the situation or stimulus persists, it is experienced as painful, physically or mentally. When the person emotionally accepts a situation or stimulus as desirable, it is not experienced as painful.* It will be noted that the hypothesis speaks of acceptance and rejection in terms of emotion rather than intellect. Many situations are accepted intellectually, but at the same time are emotionally rejected. Thus, intellectual acceptance of dentistry will bring a patient to the office, but emotional rejection will make him cringe and cry out with pain once he is in the operating chair. Whenever there is emotional rejection, there is mobilization of energy with consequent tension in the service of eliminating or avoiding that which is rejected. The organism is "set" to rid itself of this threatened danger. So the patient who knows, intellectually, that what the dentist is about to do is a good thing for him may, nevertheless, grab the arm of the dentist when his bur touches the tooth.

On the other hand, if there is emotional acceptance, there is less likely to be tension, involving the blood vessels and the pain receptors (the free nerve endings) which innervate the musculature of the vascular system. This is tantamount to relaxation. I was so relaxed during the gold-foil episode that I actually went to sleep. But it should be noted that the relaxation was the *result,* and that the cause was an emotional attitude on my part; that is to say, acceptance of the experience emotionally as desirable and desired; *feeling* the anticipated experience as good; asking for the experience not only with the head, but also with the viscera. It is apparent that we encounter semantic difficulties at this point. Our symbols for the nuances of emotional behavior and experience are so limited that it is very difficult for me to communicate what I wish to express. But once again let me emphasize that this acceptance, this asking for, this feeling the experience as good, comes from the autonomic nervous system, not from the cerebrospinal nervous system; it is emotional, not intellectual.

If I have been able at all to communicate something about this process, it should help us understand more clearly many phenomena which heretofore were very perplexing, seeming to defy and to deny many of the laws of nature and human physiology. It should throw some light on masochism. That which would ordinarily pain most of us, the masochist actually seeks out and seems to enjoy. In some extreme forms, the masochist is never more ecstatic than when bruised, beaten, slashed, and dripping with blood. Instead of emotionally rejecting this sort of thing, instead of mobilizing energy to avoid it, as most of

us would do, the masochist emotionally seeks it out, emotionally desires it, emotionally finds it good.

This should help us also to understand better the behavior of martyrs who sang even as the flames were consuming their bodies, showing no agitation nor giving any evidence of pain. I recall reading of one unfortunate fellow who was stretched on an iron grating and suspended over hot coals, to be literally roasted alive. After roasting for some time with his back to the coals, he announced in a very calm and matter-of-fact way, "I think you might turn me now. I'm pretty well done on that side." Far removed from the actual occurrence we can laugh at this. But it must be remembered, this man was being roasted alive! Here was a reversal of the common testimony of human experience. What made the difference? What made such a phenomenon possible? Many of these martyrs accepted these experiences emotionally. Some even sought them out, asking to be tortured and burned. Our interest here is that under this emotional acceptance, apparently no pain was experienced.

This hypothesis seems to throw some light, also, on psychologic pain. The emotionally rejected but persisting situation, even though it involves no physical stimulus, produces tension involving the vascular system, and is experienced as painful. Such may eventually involve physical aspects of the individual, and result in migraine, gastrointestinal disorders, and other organic dysfunction.

SUMMARY

Allow me to remind you that this is still just an hypothesis. Much further investigation is needed, involving controlled experimentation. But it does appear to the author at the present time that emotional rejection of a situation alerts the whole organism on an emergency basis; makes possible the perception of otherwise unnoticed messages from the free nerve endings, with the result that the "pain" is more intense. The organism is thus thrown into greater effort to remove the source of the pain, or to remove itself from the situation. On the other hand, emotional acceptance either is effective in inhibiting the passage of any excitation from the free nerve endings to the pain center in the brain or, in some way, to perceive the excitation not as painful, but as satisfying and desirable.

(At the conclusion of his address, Dr. Fisher demonstrated by driving a straight pin in his own leg up to the head of the pin and by forcing a hatpin through his cheek; in neither instance did he give any evidence of pain.)

University of Miami,
Coral Gables, Fla.

THE FREE-WAY SPACE AND ITS RELATION TO THE TEMPOROMANDIBULAR ARTICULATION

STANLEY G. STANDARD, D.D.S., AND JAMES B. LEPLEY, D.D.S.*

New York, N. Y., and Brooklyn, N. Y.

THE subject of this article has been selected because of the tremendous impact it has on any major oral restoration, especially in the construction of complete maxillary and mandibular dentures. Dentists have long recognized that centric relation is a fixed position which must be accurately recorded before occlusion can be developed. Centric relation has been defined as the most retruded position of the condyles from which free lateral movements can be made at a given vertical dimension. This definition is correct if we accept the concept that with every change in vertical dimension, there is a different centric relation. As a point of reference this definition becomes a variable, and thus it is of uncertain value in developing centric occlusion. Therefore, we believe a better definition would be, "The balanced position of the condyles from which free lateral movements can be made when the mandible is in physiologic rest position." This would then designate a fixed position for centric relation, and better enable us to develop the correct centric occlusion.

VERTICAL DIMENSION

Vertical dimension is a nebulous position which is often left to the good judgment of the operator. Correct vertical dimension plays an important part, not only in the improved appearance of the patient, and in the comfort derived from dentures in function, but in the developing of the correct centric occlusion.

The term "vertical dimension" is too often loosely construed to mean any distance between the upper and lower jaws. It is possible for the lower jaw to open and close over a great range. The range is limited in the opening position only by the ability of the closing muscles of the jaw to stretch to their limit, and by the ability of the depressors to contract. It is limited in the closing position by a tooth or ridge contact. Vertical dimension, as thus defined, becomes any jaw relationship between these extremes. The selection of the correct occlusal vertical dimension in denture construction has not been sufficiently stressed. A wide range of selection is left to the judgment of the operator, with a thought that too great a vertical dimension will create sequelae leading to discomfort and ridge destruction, but with little mention of the results of too short a vertical dimension. It is well

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The opinions or assertions contained in this article are the private ones of the writers and are not to be construed as official or reflecting the views of the Department of the Navy or the Naval service at large.

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 19, 1954.
Received for publication June 4, 1954.

*Lieutenant Commander (DC) U.S.N.

recognized that there must be a free-way space between the upper and lower teeth when the mandible is in rest position. The research of Niswonger[1] and Thompson[2] definitely established the physiologic rest position as a constant anatomic landmark throughout adult life. These and other investigators found that the space between the physiologic rest position and the tooth contact, in the average individual, was always constant within a range of 2 to 5 mm. when measured between the chin and nose. Sicher[3] states:

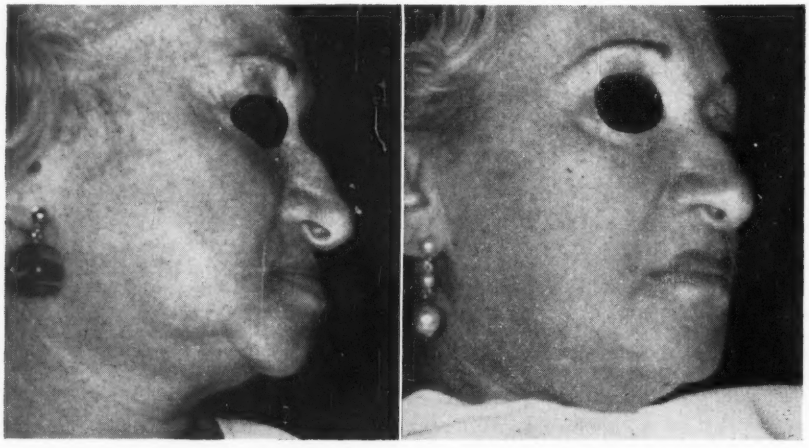
> The free movements of the jaw start from, and end in, the rest position of the mandible. In this position the lower and upper teeth are not in contact; the distance between the upper and lower front teeth in the rest position varies as a rule from two to four millimeters. The rest position is constant in each individual due to the individually fixed and only slightly variable tonus of the masticatory muscles, which, in their "relaxation," allow the mandible to drop slightly. The rest position is therefore not dependent on the presence of teeth or on their shape or position but on their musculature and on the muscular balance only.

Sicher[4] also states:

> The movement necessary to bring the jaw from centric to rest position and the reverse movement are almost pure hinge movements. The recognition of this fact is important. Any significant deviation from a hinge movement observed, for instance, in returning to the occlusal from the rest position, indicates that the occlusal position is a forced position and not a free and normal relation between lower and upper jaws. Occlusal position, in this case, is not identical with centric position.

Muscles function at their greatest efficiency only at their full anatomic length. The rest position is assumed involuntarily to rest the muscles. Boos,[5] has demonstrated, by the use of the Bimeter, that a comfortable vertical dimension with the greatest biting power can be obtained only at a very limited distance from this rest position. With the acceptance of these findings, the correct vertical dimension becomes a definte position within this range. The establishment of an occlusal vertical dimension beyond the physiologic rest position will lead to discomfort, clicking of teeth during speech, and resorption of ridges in nature's attempt to establish a normal free-way space. The selection of a vertical dimension below this range will also lead to different, but equally harmful, sequelae. Too short an occlusal vertical dimension creates a decided problem in obtaining good esthetics. It will cause a typical "denture-mouth" appearance, with thin vermilion borders, drooping of the corners of the mouth, sagging of the cheeks, and a tight convex appearance of the lips. These changes produce an appearance of aging upon the patient (Fig. 1). Dentists have been so impressed with the dangers resulting from too great a vertical dimension that many have gone to the opposite extreme in establishing one that is too short. Besides the poor esthetics, the greater danger of such a vertical dimension is the prognathic occlusion that may result from it in a very short time. It is nature's plan that, in the act of swallowing, the teeth should meet to help in the coordination of the muscles involved in deglutition. If the free-way space is too great, the lower jaw travels upward and forward in order to make tooth contact. The joint movement is no longer a simple hinge action as it would be with a normal free-way space, but a protrusive element is incorporated. It is our belief that this continual reaching for a comfortable tooth contact position leads to this prognathic result. Occlusal vertical dimension is thus intimately

related to correct centric occlusion. Unless the occlusal vertical dimension is kept within the range of a normal free-way space, it is impossible to obtain a true centric relation record. The correct occlusal vertical dimension position is "that relation, with upper and lower teeth in contact, which is as close to the physiologic rest position as speech and function will permit." Accepting the fact that centric relation is a fixed position that can be recorded accurately, we shall endeavor to prove that vertical dimension can also be a fixed position which can be recorded for every individual patient.



A. *B.*

Fig. 1.—*A*, The result of full dentures with too short a vertical dimension. The teeth are in contact. The free-way space is 6 mm. Note the prognathic occlusion that developed within a two-year period. *B*, The correct vertical dimension is restored with new dentures. No change in occlusion has occurred in five years.

STRUCTURES INVOLVED IN JAW RELATIONS

Let us have a clear understanding of the structures involved in recording centric relation and vertical dimension, and the establishment of the correct free-way space. The temporomandibular articulation is a complex joint in which two basic movements of the mandible can be distinguished.

1. The rotary or hinge movement which is a rotation of the mandible around a horizontal axis in the frontal plane and passing through the centers of the condyles. This movement occurs between the disc and the condyle lower compartment of the temporomandibular articulation.

2. The translatory or sliding movement. This movement may be symmetrical or asymmetrical. The translatory movement occurs between the temporal bone and the disc in the upper compartment of the temporomandibular articulation.

During opening and closing, the translatory and rotary components are not evenly combined. The opening movements starts with an almost pure rotary or hinge movement which depresses the mandible to, or slightly beyond its rest position. From then on, the two components combine in a smooth movement. After

maximal opening of the mouth, the closing movement commences with a phase in which the translatory movement, in a backward direction predominates. In this way, the mouth is closed about two-thirds of its maximal opening. At the same time, the head of the condyle is brought from the anterior slope of the articular tubercle to the height of the tubercle or to the posterior slope of it. The last one-third of the closing movement occurs in the smooth combination of translatory and rotary movement. The muscles which contribute to the different movements of the lower jaw may be divided into three groups: (1) the elevators and retractors, (2) the depressors and retractors, and (3) the protractors.

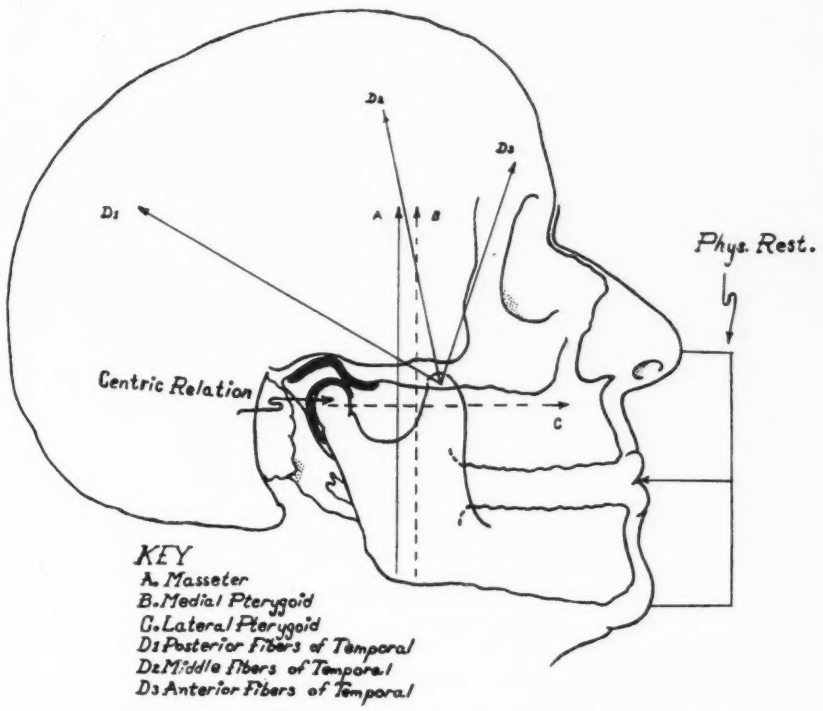


Fig. 2.—The mandible is in centric relation and in the physiologic rest position. The condyle is balanced against the eminentia articularis by the reciprocal action of (*A*) the masseter, (*B*) the medial pterygoid, and (D_1,D_2) the fibers of the temporal muscles, and opposed by (*C*) the lateral pterygoid muscle.

The elevators of the lower jaw are the masseters, temporal, and internal pterygoid muscles (Fig. 2). The resultant force of these muscles is directed upward and slightly forward. The position of the molar teeth is such that their long axes coincide with the direction of the resultant force. The depressors and retractors of the jaw are the digastric, mylohyoid, and geniohyoid muscles. The action of these muscles, spanning from the movable hyoid bone to the mandible, is dependent upon the changing position of the hyoid bone in relation to the mandible. The hyoid bone, in turn, is held in position by a group of infrahyoid muscles. The

third group of mandibular muscles is represented by one muscle only on either side. The external pterygoid muscle has a simple protracting effect upon the mandible. Since this muscle is attached to the pterygoid groove below the mandibular condyle and to the articular capsule and the articular disc, the muscle will influence the position of the disc also.

With this rather sketchy outline of the temporomandibular articulation and the muscles involved in its movement, we reach the following conclusions:

1. There is a physiologic rest position which is constant in each individual represented by the equilibrium of the muscles that elevate the mandible and the depressors that depress it. When these muscles are in equilibrium, the jaw assumes a position which is fixed and constant for every individual, and which can be recorded.

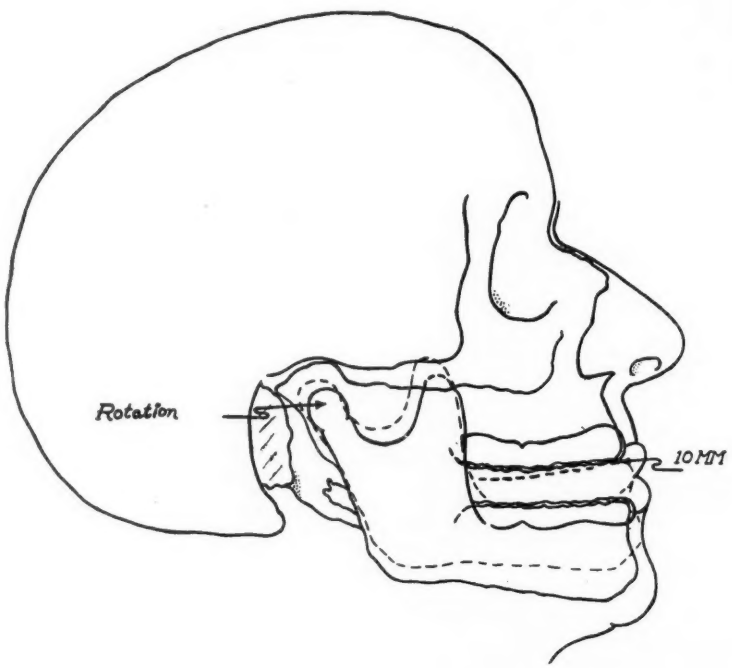


Fig. 3.—With 10 mm. of closure, the condyle rotates and moves backward and upward, and the chin and lower lip protrude. The mandible is in an unbalanced position.

2. The opening and closing of the jaws, within a limited range above and below the physiologic rest position, is a pure hinge movement (Fig. 3). If the jaws are opened beyond the physiologic rest position, the muscles are stretched, and Nature attempts to restore muscular equilibrium at the expense of the bony structures. Also, if the jaws are closed to too great a degree below physiologic rest, the muscles are abnormally contracted and apply pressure to their bony attachment beyond that

which Nature intended. Applying Wolff's law which states that the external form and internal structure of living bone is determined by the muscular forces put on it, we might expect changes in the position of the condyle and the meniscus, and even in the angle of the mandible. This would then explain the phenomenon of prognathism that develops when dentures are constructed with less than a normal vertical dimension.

When the hinge movement of the jaw ends, a translatory movement of the condyle begins as the jaw is opened. The condyle and the meniscus are pulled forward toward the height of the articular tubercle. Since the directing force of the muscles of mastication are upward and slightly forward, the pull will then be directed against the head of the condyle on the posterior slope of the articular tubercle, and may create a bend at the neck of the condyle. Also, with the teeth acting as a stop, the pull may be such as to create a bend at the angle of the jaw in time. This would not only explain the prognathic movement that results, but it might account for the various symptoms that manifest themselves when the occlusal vertical dimension is too short, such as, pain in the ear, tinnitus, and other associated discomforts. These may be due to the backward bending of the neck and the displacement of the head of the condyle which are created by the changes produced by abnormal muscular forces.

METHODS FOR DETERMINING THE VERTICAL DIMENSION

Many methods have been used for determining the vertical dimension. The phonetics method is based on the assumption that there is a direct connection between the interdental space, occlusal plane position, and tongue position, during articulation of speech. The patients are instructed to use words with the letters *S* and *M* and the sound *Ch* in them. It is assumed that words and sounds can be produced if these relationships are correct. The method, however, seems to have limited value, because the patient has an empty mouth and would need time to accustom himself to the additional bulk of trial dentures.

The tactile sense method is based on the assumption that a person will remember, by tactile sense, the exact position at which the natural teeth had occluded, even for a long time after the teeth have been lost. The reactions of most patients, however, are not reliable and, therefore, cannot be of great value.

In another procedure, the physiologic rest position is used as a guide. The physiologic rest position of the jaw is the position in which both the depressor and the elevator muscles are theoretically in tonic balance. It is always the same position. Therefore, a registration of the jaw in this physiologic rest position should record a relatively correct degree of vertical dimension. However, the physiologic rest position is not an exact position.

Park[6] assumed that the head of the condyle traveled forward toward the eminentia, simultaneously with the start of the opening movement of the mandible, when the first slight separation of the teeth occurred. He devised a method to determine vertical dimension based upon this assumption. The lower occlusion

rim was made much too high. A retrusive checkbite was made in the mouth, and a mark was drawn on the sides of the occlusion rims. The lower occlusion rim was then shortened until a forward movement resulted. The height of the lower occlusion rim was then increased, by successive stages, until the marks on the sides were again continuous. This was considered to be the occlusal vertical dimension. The error was that the center of rotation was considered to be a line on the level of the occlusal plane, posterior to the ramus.

Armstrong[7] reported a more scientific method of establishing normal vertical dimension according to Parks' theory. This was done by attaching a metal plate on the palatal surface of the upper occlusion rim. A metal plate, with a central bearing screw near the center, was mounted on the lower occlusion rim. When these occlusion rims were placed in the patient's mouth, the mandible was held in an open position by the central bearing screw on the lower occlusion rim being in contact with the flat metal plate on the upper occlusion rim. The patient was instructed to maintain this contact and move the mandible several times to the right, left, and protrusive positions. This series of movements recorded a needle point tracing on the upper metal plate, and centric relation was recorded by means of a checkbite made in this opened position. The occlusion rims were removed, and a small round hole was cut at the apex of the tracing. The central bearing screw on the lower occlusion rim was lowered until the vertical dimension was closed. The relation of the central bearing screw to the hole was checked to determine whether the point of the screw had moved forward from the hole in the upper bearing plate. The patient was asked to record another tracing to make sure that the jaw had not been protruded by mistake. By lowering the screw, the vertical dimension had been reduced and the point of the central bearing screw had moved forward from the hole. Somewhere between these two extremes is the position that the mandible assumes when the condyles are in their normal relationship to the fossae. The central bearing point was raised one turn and the patient was directed to develop a tracing which would make sure that the mandible is in its most retruded position. This operation was repeated until the point of the screw re-engages the hole of the upper metal bearing plate. When the point of the screw re-engaged the hole, both the normal vertical dimension and centric relation were established. The occlusion rims were locked in this position by injecting plaster of Paris between the metal plates. The error in this method is that the beginning of the translatory movement of the lower jaw, in its closed position, was accepted as the occlusal vertical dimension. Neither Parks nor Armstrong gave consideration to physiologic rest position as a point of reference.

The procedure that we suggest is similar to that of Armstrong, but it is based on the following principles:

1. That physiologic rest position is constant. It is a position which can be recorded.

2. That the movement of the head of the condyle is a hinge movement in the range from a position somewhere below the physiologic rest position to a point above it.

3. That between the physiologic rest position and the beginning of the translatory movement of the condyle in its closed position, the true occlusal vertical dimension can be recorded.

TECHNIQUE OF RECORDING VERTICAL DIMENSION

Adequately fitting baseplates for both upper and lower jaws are necessary. These baseplates should be made of some stable and tough material that will resist distortion. They may be made of self-curing acrylic or shellac baseplate material. They should be stabilized so that they fit both the cast and mouth accurately.

A Ballard tracer which consists of a metal plate in which a tracing point is inserted through a threaded hole is attached by modeling compound to the lower occlusion rim. A metal plate is attached with modeling compound to the upper occlusion rim.

Then the physiologic rest position of the jaw is recorded. This is accomplished by placing a square of adhesive tape on the tip of the nose, and another on the point of the chin. A mark is made on the upper and lower tapes with indelible pencil. With either an upper denture or an upper occlusion rim in the mouth, the patient is requested to wet the lips with the tongue, and assume a relaxed position of the lower jaw. With a pair of calipers, the distance between the two marks is measured. This procedure is repeated a minimum of five times. Any three recordings that are similar are accepted as the physiologic rest position. The baseplates with the Ballard tracing device are then inserted in the patient's mouth. The screw is raised or lowered until the physiologic rest position is maintained when the screw contacts the upper metal plate.

The patient is then requested to move jaws laterally and protrusively until a needle-point tracing is registered on the upper bearing plate. The upper baseplate is removed and a small hole is made in the metal plate at the apex of the tracing. The baseplate is then returned to the mouth; the patient is requested to make the same jaw movements until the point of the screw is locked in the hole in the metal plate. This position is accepted as centric relation. (Centric relation is defined as the balanced position of the condyles from which free lateral movements can be made when the mandible is in physiologic rest position [Fig. 2]).

The lower occlusion rim is removed and the screw is lowered one turn. Then the occlusion rim is replaced in the mouth, and the patient is asked to repeat the lateral and protrusive jaw movements. This procedure is repeated, each time lowering the screw one turn, until the point of the screw no longer engages the hole in the upper occlusion rim. The patient is asked to hold the jaws in this position (with the screw touching the upper metal plate), and the calipers, which are set to the same distance as for the previous measurement, are used to locate a second point on the tape on the chin. This point will be below the first mark. This lower point is marked on the tape on the chin with indelible pencil. Then the distance between the two marks on the lower tape is measured. This distance then becomes the end of the rotary movement of the condyle from the physiologic rest position to the level at which a translatory movement begins. We may then assume that the true occlusal vertical dimension is at a position somewhere between these two points.

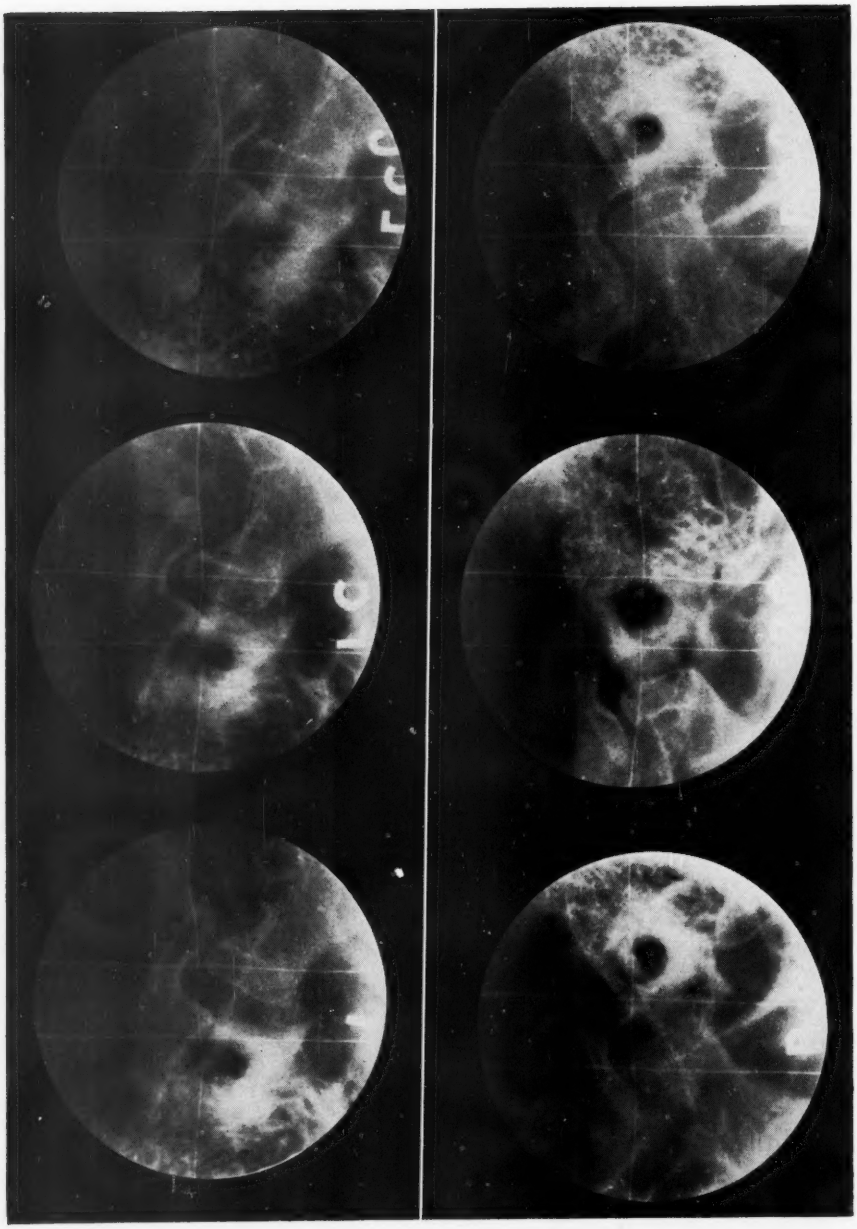


Fig. 4.—Roentgenograms of left and right temporomandibular joints *(L)* and *(R)* were made at physiologic rest position. Note the position of the condyle below the eminentia. *(LC)* and *(RC)* were made with 5 mm. of closure from rest position. Note that the condyle has moved slightly upward and backward. *(LCC)* and *(RCC)* were made with 10 mm. of closure from rest position. Note that the condyle has rotated and moved further up and back by displacing structures within the glenoid fossa.

EFFECTS OF REDUCED VERTICAL DIMENSION

It has been said that when the vertical dimension is shortened, the mandible is permitted to be thrust upward and backward. We do not believe this is completely true. From an open position up to the physiologic rest position, the mandible is thrust upward and backward in closing, but at a point near or at the physiologic rest position, the mandible rotates until it reaches a point above the physiologic rest position. Then in further closure, the condyle endeavors to slide upward and forward. This statement we believe to be important. It is the antagonistic pull of the muscles against the mandible in this abnormal position (in which the condyle is resting against the posterior slope of the eminentia articularis) that tends to create bone changes. By this pull, the condyle may be bent backward, or a change may take place at the angle of the mandible. These changes may lead to continuous and progressive disturbances.

RESEARCH METHOD

To prove our theories, the following research was conducted through the facilities of the Prosthetic Dental Residency of the Naval Dental Clinic in Brooklyn.

Twenty edentulous patients ranging in age from 25 to 65 years were selected over a period of six months. Impressions were made of the upper and lower jaws of each patient, and closely fitted plastic bases were adapted to the casts. Onto the lower base, a Ballard tracer was attached with modeling composition. A flat metal plate was attached to the center of the palate of the upper base. Two small holes were drilled into the buccal flanges of both baseplates with a No. ½ round bur at about the cuspid and second molar regions. Small squares of adhesive tape were attached to the point of the nose and the chin, and the physiologic rest position was determined and marked. The bases with the tracer attached were inserted in the mouth, and the point of the tracing screw was adjusted so as to maintain the physiologic rest position. A needle-point tracing was made, and a small hole was drilled with a No. ½ round bur into the metal plate at the apex of the tracing. The bases were reinserted, and the patient was instructed to move the lower jaw until the point of the tracer was locked in the hole. The physiologic rest position was checked again to be sure there had been no change. This was done by measuring the distance between the marks on the tapes on the point of the chin and the nose, and the distance between the holes on the buccal flanges of the bases at the cuspid and molar regions. The screw was lowered 1 mm. at a time until its point no longer entered the hole in the metal plate. The distance the screw could be lowered varied with each patient. The distances ranged from 2.9 mm. minimum to 5.0 mm. maximum.

The experiments were carried further by shortening the screw between 8 and 10 mm., which was the usual limit of closure without contacting the bases (Fig. 3). A new tracing was obtained at this vertical dimension, and a hole was drilled at the apex of the tracing to maintain the position. Using an Updegrave 15 degree angle board, temporomandibular roentgenograms were made in four positions: (1) at physiologic rest, (2) at the end of the vertical movement, (3) at a posi-

tion with 8 or 10 mm. of free space, and (4) at extreme closure measuring up to 22 mm. without the bases in the mouth (Fig. 4).

The purpose was to determine if we could observe any change in the position of the condyle. We could discover no appreciable change in the position except in extreme closure. The condyle appeared to have rotated, and to be cradled in a position further back and in the fossa.

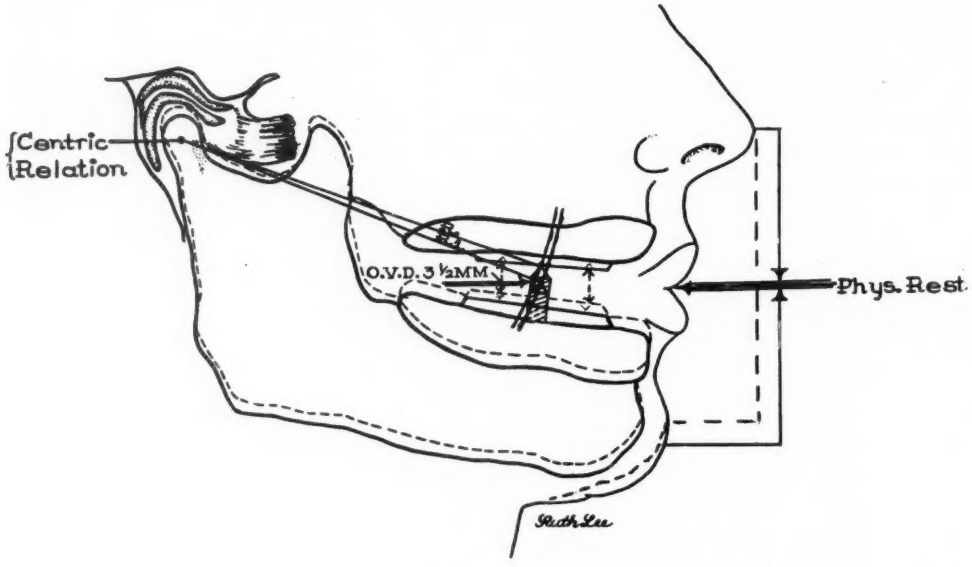


Fig. 5.—Diagram of bases in the mouth with the needle-point tracer attached showing the radius (*R*) from the axis to the point of the tracer at physiologic rest position, and radius (*R 1*) when the pin is lowered 3.5 mm. If the mandible rotates, a new needle-point tracing would be scribed forward from the first one. The same tracing was scribed for both positions indicating that the axis had moved to compensate for the increased length of the radius.

DISCUSSION

We reason that if, as we thought, the condyle was rotating only during this closing movement, the point of the tracer was describing an arc with a radius of the distance from an axis through the condyle to the point of the tracer (Fig. 5). If this was true, the radius was increased when the point of the tracer was lowered. Therefore, the tracer point should leave the hole immediately and strike the plate forward of it when the vertical dimension was decreased. Since the point returned to the hole after a change of as much as 5.0 mm., we sought some other explanation. The only changes that could account for this were a straight backward or an upward movement of the condyle, to compensate for the increased radius. It is impossible for the condyle to move backward, since the muscles involved in this closure are all directed upward and forward. Therefore, we concluded that the first movement, of the condyle and the entire body of the mandible from physiologic rest position, was straight upward to a position where the synovial fluid could no longer be displaced, and where the head of the condyle

would be braced against the articular disc and the posterior slope of the eminentia articularis by the reciprocal action of the muscles of mastication. The masseter, internal pterygoid, and the middle and anterior fibers of the temporal muscles exert an upward and forward force. The external pterygoid muscles pull straight forward, and the posterior fibers of the temporal muscles create a reciprocal force backward from their attachments on the coronary processes. The head of the condyle is thus held in a favorable position to dissipate the resultant of muscular forces applied at the point of contact of the teeth.

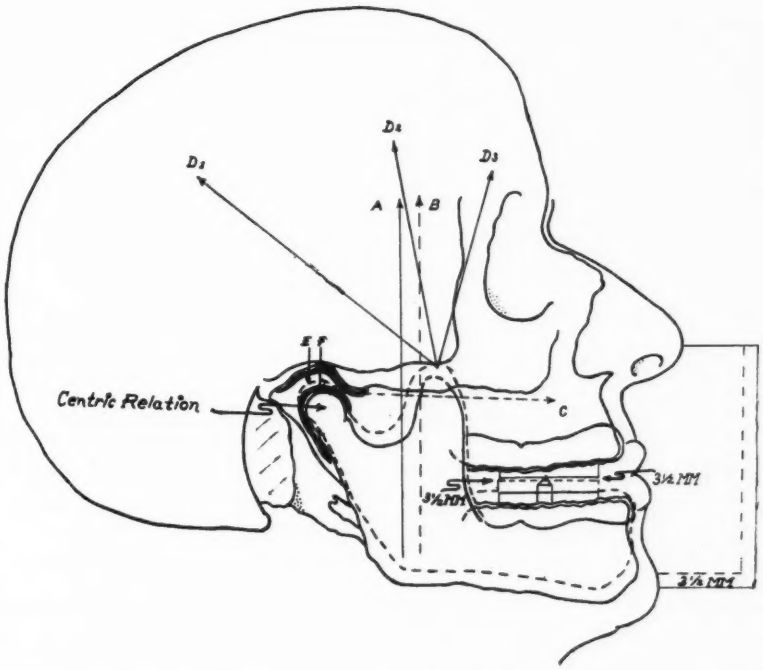


Fig. 6.—The condyle is balanced against the slope of the eminentia at the end of the vertical displacement of mandible; 3.5 mm. of closure is identical in measurements between the nose and chin, and between the bases at the cuspid and molar regions. (*E-F*) indicates the range of vertical displacement of the condyle.

The results of this investigation completely change our previous concept that the first movement of the condyle from physiologic rest to occlusal contact, and the reverse, is a pure hinge movement. Instead, these findings definitely indicate that the condyle and of course the entire mandible move vertically for a distance which varies from 2.9 to 5 mm. in different individuals. As a further corroboration of this, the measurements made outside the face, and between the holes on the bases at the cuspid and molar regions, and also at the pin itself, all coincided.

The temporomandibular articulation should be considered as a neuromuscular mechanism.[8] The muscles involved hold the head of the condyle in a balanced position on the posterior slope of the eminentia articularis within the range of vertical displacement. Any other position should be considered as unbalanced (Fig. 6).

Centric occlusion could then be defined as a tooth contact position in which the head of the condyle is balanced in the glenoid fossa within the range of vertical displacement. Therefore, we reached the conclusion that the distance between physiologic rest position and the end of this vertical movement represented the maximum amount of free-way space to be established for each individual.

CONCLUSIONS

1. Physiologic rest and centric relation as defined in the context are points of reference that can be used to obtain an accurate and definite occlusal vertical dimension.

2. The first movement from physiologic rest to occlusal contact is an upward vertical displacement.

3. The distance between physiologic rest position and the end of this vertical movement is the maximum amount of free-way space to be incorporated in any oral prosthesis.

4. Further closure results in a rotating of the condyle around its axis, with further backward and upward movement creating an unfavorable position of the condyle for withstanding crushing forces.

5. Continued forces applied with the condyles in such unbalanced positions may result in bone changes at the neck of the condyle, or at the angle of the mandible, and may create a prognathic occlusion and other temporomandibular disturbances.

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225 West 34th St., New York 1, N. Y.
U.S. Naval Dental Clinic, Naval Base, Brooklyn 1, N.Y.

AIDS IN TEACHING LAWS OF ARTICULATION

EARLE S. SMITH, D.D.S.*

State University of Iowa, College of Dentistry, Iowa City, Iowa

INTERPRETATION and application of the "laws of articulation" are often found difficult by students of dentistry. Memorization of the laws is done many times. Mere memorization still leaves the student with no clear conception of *why* the laws operate.

A simple gadget, which can be easily and economically made, has been found helpful in the classroom to demonstrate the interrelationship of three of the basic factors involved in arranging teeth—condylar guidance, incisal guidance, and compensating curve. The influence of cusp height and plane of orientation cannot be demonstrated by this gadget.

Three pieces of wood, each approximately three-fourths inch square in cross section and eight inches long, are attached to a piece of corrugated cardboard by means of short bolts equipped with fly nuts. Two of the pieces, one to represent the maxillary incisors (Fig. 1,*A*), and one to represent the maxillary posterior teeth (Fig. 1,*B*), are attached on the same horizontal level. The piece to represent the condylar guidance (Fig. 1,*C*), is attached at a higher level and farther back. Each piece is attached by passing one of the bolts through a hole midway between the ends of the piece, thence through the cardboard to be tightened in position by the fly nut on the opposite side of the cardboard.

The part to represent the mandible is constructed of pieces of wood similar in cross section to those forming the maxillary elements. Preparatory to the construction of the mandible, the maxillary parts are placed in horizontal positions. A piece of wood to represent the body of the mandible is placed a short distance below and parallel to them. The three pieces are of such length that when they are attached vertically to the piece representing the body, the upper ends can make contact with the maxillary elements near their midpoints and are prepared and nailed to the piece representing the body (Fig. 1,*D*).

With the maxillary and mandibular parts in contact as shown (Fig. 1), balanced centric occlusion is represented. If the mandible is now moved protrusively (Fig. 2), it will be noted that contact in all three areas—condylar guidance, compensating curve and incisal guidance—is being maintained. In other words, if the condylar guidance is zero, and if no vertical overlap is being employed, no curvature in the compensating curve area is needed.

Presented as a clinic before the Academy of Denture Prosthetics, Miami Beach, Fla., April 16, 1954.

Received for publication July 12, 1954.

*Professor Emeritus.

If inclination is now given the piece representing condylar guidance (Fig. 3,*C*), and then the mandible is moved protrusively (Fig. 4), it will be noted that, while contact can be maintained in the condylar guidance area and in the incisal guidance area, separation takes in the compensating curve area (Fig. 4,*B*), necessitating an increase in the inclination of the piece representing the compensating curve (Fig. 5,*B*). In other words, "an increase in the condylar guidance increases the prominence of the compensating curve."

Fig. 1.

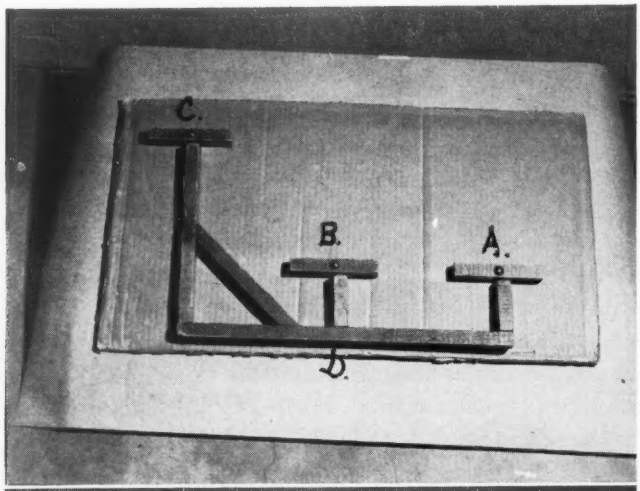

Fig. 2.

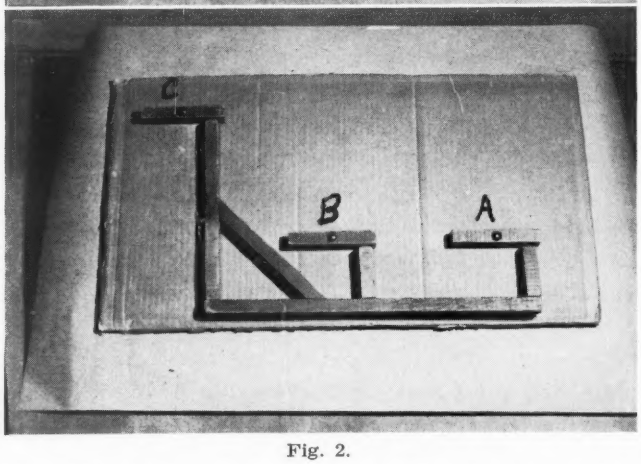

Fig. 1.—Gadget useful in demonstrating "laws of articulation." *A*, Incisal guidance area; *B*, compensating curve area; *C*, condylar guidance area; *D*, mandible. As positioned, parts are in centric occlusion.

Fig. 2.—Protrusive occlusion. No separation between any of the parts, indicating that when condylar guidance is flat and there is no vertical overlap in incisal guidance area, no compensating curve is needed.

In similar manner, the interrelationship of these three factors in formulating other "laws of articulation" can be analyzed.

Another simple device to demonstrate the relationship not only of the factors condylar guidance, incisal guidance and compensating curve, but to include the plane of orientation as well, is a simple diagrammatic drawing of a set of scales with two weights occupying each of the scales pans (Fig. 6).

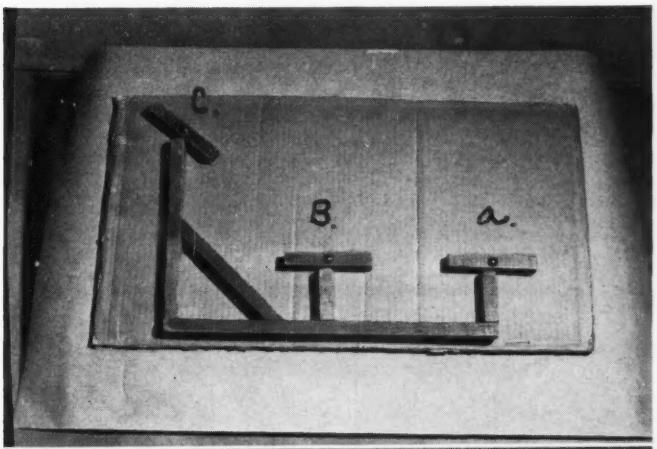

Fig. 3.

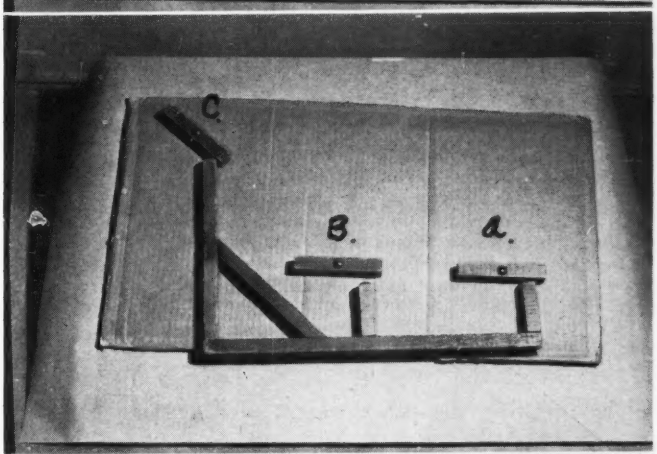

Fig. 4.

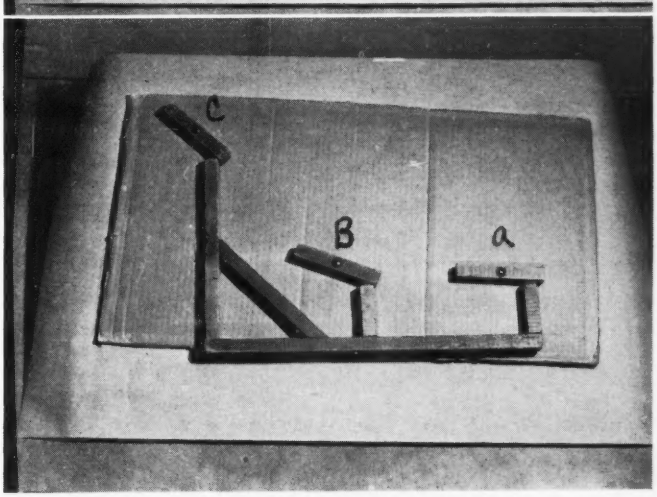

Fig. 5.

Fig. 3.—Condylar guidance increased. Centric occlusion.

Fig. 4.—Protrusion. Separation between mandibular and maxillary elements takes place in compensating curve area.

Fig. 5.—Balance restored by increasing inclination in compensating curve area.

Since an inclination in the condylar guidance area during protrusion causes a downward or "opening" movement of the mandible from the maxilla posteriorly, and vertical overlap of the anterior teeth causes a downward or "opening" movement anteriorly, CG, or condylar guidance, and IG, or incisal guidance, may be considered as the weights occupying one of the scales pans. To counterbalance or compensate for these opening influences, CC, or compensating curve, and PO, or plane of orientation, may be considered as the weights occupying the pan on the opposite side of the scales (Fig. 6).

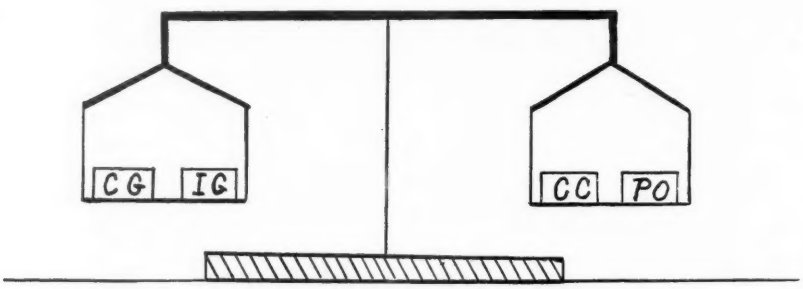

Fig. 6.—Diagrammatic representation of a set of scales in balance. Weights CG and IG representing condylar guidance and incisal guidance, two factors involved in causing separation between mandible and maxilla during protrusion, in pan on one side of scales. Counterbalanced by weights CC and PO, compensating curve and plane of orientation, in pan on other side of scale. Changing the amount of any one weight will disrupt balance. Balance can be restored by changing any of the other weights; depending on the way the scales move, it can be reasoned whether an increase or a decrease is indicated.

With the scales in balance, it is self-evident that an increase in any one of the weights will disturb the balance. It can be reasoned readily that balance can be regained by reducing the other weight on the same side of the scales or by leaving it alone and increasing one or the other of the weights in the pan on the opposite side of the scales.

Having the scales in mind but attaching no significance to the symbols ($+$ and $\rightarrow$) other than as a means of gathering the factors together, the various laws in which these factors are involved can be expressed as follows:

$$CG + IG \rightarrow CC + PO \quad \text{(Scales in balance)}$$
$$Inc.CG + Dec.IG \rightarrow CC + PO^{*}$$
$$Inc.CG + IG \rightarrow Inc.CC + PO$$
$$Inc.CG + IG \rightarrow CC + Inc.PO$$
$$CG + Inc.IG \rightarrow Inc.CC + PO$$
$$CG + Inc.IG \rightarrow CC + Inc.PO$$
$$CG + IG \rightarrow Inc.CC + Dec.PO$$

The two methods which have been described have been found useful in promoting logical reasoning relative to the factors involved in the "laws of articulation," and this is deemed preferable to a dependence on memorization.

State University of Iowa, College of Dentistry
Iowa City, Iowa.

*An increase in the condylar guidance weight can be balanced by a decrease in the incisal guidance weight. Expressed as a law: "An increase in condylar guidance decreases the incisal guidance." In similar manner, interpretation of the other equations can be made.

MUTUAL PROBLEMS OF THE PERIODONTIST AND PROSTHODONTIST

J. S. McKenzie, D.D.S.

Miami, Fla.

THE INTERRELATION of the periodontists' and prosthodontists' problems has been known for many years.[1] History, as far back as 3,000 B.C., records "individuals who were concerned with the prevention, diagnosis, and treatment of diseases of the teeth and adjacent tissues, and who restored missing dental and oral structures." Since then, the dependence of the specialties of periodontics and prosthodontics upon each other for successful practice has been increasingly recognized. The roles played by the full denture specialist and periodontist are noble and indispensable but are specialties at least partially supported by the neglect and carelessness of the dental profession. No doubt, many fully edentulous mouths are unavoidable, but countless others certainly could have been prevented by a more thorough understanding of oral health problems by both the dentist and the patient.

Since it is the partially edentulous mouth with which this article deals primarily, it must be emphasized that far too many patients are ruthlessly made permanent dental invalids by extraction of serviceable, key abutment teeth, or ones that could be made serviceable with intelligent care. Preventing or postponing the loss of the entire natural dentition in many individuals would not only allow more comfort, but would also increase their feeling of security and self-confidence, and prevent dental and mental cripples.

The complexity of oral function and the various mechanisms involved in it becomes more and more apparent on close study. Each minute part of it, its structure and function, seems to fall into place like pieces of a complicated puzzle. The normal relation of the condyles to the glenoid fossae is encouraged by muscular equilibrium. This, in turn, is influenced by simultaneous balanced contact of the lower teeth against the upper teeth when the lower jaw closes in true centric relation. This closure is made from an imaginary hinge axis on or near the condylar heads, and pressure on the posterior teeth is expressed along their long axes.

ARCHITECTURE OF THE JAWS

Even the curve of the dental arch, the shape of the teeth, and the bone anatomy are planned by nature for maximum strength and function. When the crowns of the lower posterior teeth are viewed from an occlusal aspect, it be-

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 12, 1954.
Received for publication June 17, 1954.

comes evident that the wedge shape of them prevents their lingual displacement on the chewing, or working side, when they are positioned normally in the curve of the lower arch. Instead, they are braced against each other, and offer very little pressure on the lingual bone. This explains the thinness of this bone. In contrast, the buccal plate of bone of the mandible is dense and bulky, so that buccal pressure from the balancing tooth contacts can be physiologically withstood, since no wedging action of the teeth is present in this direction.

The maxillary teeth and bones show an equally specialized architecture. The roots are longer and larger, and are more numerous and tripod-positioned in the upper molars where pressure is greatest. The enveloping bone, while not as dense, is much bulkier. The upper cuspids, which normally are the guiding teeth in occlusal wear, are protected by the canine eminences. To impair or destroy any of these functions or parts is to jeopardize normal function and health of the entire dental apparatus. Nature's plan of dental harmony must be kept in mind at all times in making restorations of lost parts and preserving the remaining teeth, as harmonious function of the entire structure depends on normal performance of each part.

DIAGNOSIS OF THE INDIVIDUAL PATIENT

A patient usually presents many perplexing and complicated questions that must be answered if the oral health problem is to be solved successfully. Roentgenograms, articulated study casts, and a thorough examination with a periodontal pocket probe are essential preliminary steps. A complete case history of the individual peculiarities of the patient, the systemic background, health history, and dietary habits are also essential.

The patient should be observed and questioned regarding mouth habits. Since very few individuals are without some form of mouth habits, it is important to note that these can create periodontal pathology. These habits are usually unconscious acts. Consequently, close observation by the dentist is usually more diagnostic than is interrogation of the patient.

Bruxism often accompanies malocclusion involving premature centric contacts, and is usually relieved by occlusal equilibration.

Periodontal pockets are divided into three groups:

1. The gingival pockets, where only the gingivae are involved.
2. The deeper periodontal pockets, which may involve severe bone loss.
3. The infrabony pockets.

Treatment planning, then, will depend on an evaluation of the type of pocket approximating each individual tooth. Gingival pockets are caused by an increase in size of the marginal gingivae, and no detachment of them exists. Frequently, the only treatment necessary is thorough scaling of the teeth, and institution of better mouth hygiene.

When the pockets are found to be deeper and alveolar bone is involved, an entirely different approach must be made. This will usually consist of curettage of the pockets or elimination of them by gingivectomy. The choice of treatment

should be determined by: (1) the depth of the pocket, (2) the anatomy of the pocket, and (3) the consistency of the gingival tissue.

Curettage is the treatment of choice when the gingival tissue is inflammatory and hypertrophied, and the gingival pocket can be expected to be reduced to normal or near normal depth by an elimination of swelling, and reattachment in the pocket sulcus area. This approach is also indicated in narrow vertical pockets, as reattachment is more probable than in the broad, horizontal type.

Gingivectomy, or surgical removal of the affected gingival tissues, is usually the accepted treatment in deep horizontal pockets, in which normal depth will not result from curettage. Fibrous, hyperplastic gingival tissue, existing even in shallow involvements, is more expediently and thoroughly treated by gingivectomy.

Advantageous use of gingivectomy by the prosthodontist is often possible, even when a periodontal problem does not exist. He is sometimes faced with the problem of utilizing abnormally short clinical tooth crowns as abutments, whether it be for supporting a clasp or precision attachment. These teeth might be short from attrition or maldevelopment, but have normal roots in sound bone. A simple gingivectomy frequently transforms these teeth into usable teeth by increasing the clinical crown length, thereby giving the operator sufficient area for a satisfactory clasp or restoration.

An infrabony pocket may be defined as any periodontal detachment that extends below the level of the crest of the supporting bone. Eradication of this type of involvement frequently can be accomplished by curettement of the pocket, gingivectomy with accompanying reduction of the bone crest to the base level of the pocket, or partial reduction of the pocket tissue by gingivectomy, followed by curettage. Needless to say, any existing occlusal trauma must be eliminated.

Infrabony pockets too often involve the trifurcations of the upper molars. Extraction of these teeth is not necessarily indicated, but the prognosis is poor, and partial denture planning in mouths retaining these involved teeth should include some thought of easily and economically replacing them when lost.

Fortunately, in most cases, the response of the infrabony pocket to treatment is usually satisfactory, and sometimes, dramatic. Complete osseous regeneration is often noted, with accompanying clinical reattachment.

PROGNOSIS IN THE INDIVIDUAL PATIENT

The diagnostician must decide which teeth are essential key teeth in the fabrication of a successful partial denture prosthesis. Many times, a key tooth can be saved by competent periodontal treatment and will remain a healthy, functioning abutment for years. This consideration is essential in treatment planning.

FIXED SPLINTING

Chayes[2] said: "Fixed bridgework is bad for the human mouth because fixation is bad and uncalled for in any situation, position, and relation with anything which lives and functions." The writer feels that this statement can only be interpreted as a condemnation of fixed splinting and was given in all

sincerity. He also believes, however, that if Chayes had been privileged to observe fixed splinting of periodontally weakened teeth as it is now frequently performed and tissue change toward normalcy by this stabilization, thereby affording opportunities to retain weakened abutment teeth to carry the attachments he so scientifically designed, his concept would have been different.

It has been said by some that fixed splinting immobilizes teeth to the extent that physiologic movement is impossible and is, therefore, contraindicated. It is readily agreed that there is some movement in teeth with normal periodontal tissues that is physiologic. But surely, in a periodontally weakened process where teeth are excessively mobile due to supporting bone loss, and where the periodontal membrane fibers are traumatized by stretching and suppression on function of these teeth, movement ceases to be physiologic and becomes pathologic.

Indiscriminate full coverage of normal teeth where cervical gold or porcelain margins are thoughtlessly or ignorantly pounded into place past the gingival attachment, thereby causing irreparable damage, is certainly not condoned. This type of splinting creates a periodontal problem instead of eliminating one and hastens the loss of teeth.

Fixed splinting with cast gold inlays, three-quarter or full crowns, or a combination of these, with the anatomy properly restored, occlusion corrected, contacts soldered high toward the occlusal surfaces, and with good margins finished just short of the gum tissue, and an appreciative patient, thoroughly schooled in mouth hygiene, make a combination assuring oral health for years to come.

OCCLUSAL EQUILIBRATION

Trauma has been defined as an injury to the body caused by violence. Trauma cannot be evaluated since it is in direct proportion to the resistance of the individual or its part. It is possible for the gentle, steady pressure of an aneurysm to create absorption of bone in close proximity to it, while it is also possible for an exaggerated malocclusion to show no radiographic or visible effect on the supporting dental structures.

Occlusal equilibration can best be approached by keeping these facts foremost in mind: (1) the problem is primarily a mandible-to-skull relationship, and (2) the technique used in balancing and final intercuspation of teeth is influenced wholly by this relationship.

Our ultimate objective should be simultaneous, balanced contact of the mandibular and maxillary posterior teeth, with pressure equalized and exerted apically in centric closure. Contacting points should be positioned so that the longest, uninterrupted functional plane possible is established in lateral excursions of the mandible. The incisal edges of the lower anterior teeth should contact the cingula of the upper anterior teeth, and may function lightly in lateral excursions. The lower incisal edges should also glide evenly and without interruption over the lingual surfaces of the upper anterior teeth from the centric contacting position to end-to-end contact on protrusion of the mandible. Only with these objectives can maximum harmony be achieved in every patient.

It is of prime importance that cuspal disharmony be eliminated in the partially edentulous mouth before impressions are made for any contemplated partial denture prosthesis, and repeated for final corrections after the insertion of the denture. With this harmony, the life of the periodontally weakened abutment teeth can be extended, and success of the prosthesis assured.

ORAL HYGIENE

Regardless of treatment approach, the objectives of periodontal treatment are the same in all patients, e.g., elimination of the pockets, the return to health of the tissues, and maintenance of this health. Without adequate training of the patient in a technique of proper mouth care, and diligent cooperation in this care, results will, at best, be only temporary. Abutment teeth are more vulnerable to foreign deposits, and require extra attention. In instructing the patient, emphasis should also be placed on the necessity of a scrupulously clean partial denture prosthesis at all times, especially within the clasps, for without it, debris is continually held in apposition to the teeth and soft tissues, inviting decay and a return to periodontal disease.

It is obvious that a routine procedure of oral hygiene cannot be followed in all partially edentulous patients as is possible in most mouths with complete natural dentition. Variations are necessary so that an isolated tooth or groups of teeth will be thoroughly cleansed, and the supporting gingivae will be stimulated adequately.

The recently introduced multitufted nylon brushes with large heads are most advantageous in caring for partially edentulous mouths. These bristles, properly applied, offer uniform stimulation and cleansing action to the teeth and gingival crevices.

It is important to emphasize a definite sequence of areas brushed in teaching mouth hygiene. This assures more even and adequate coverage. Brushing should begin, for instance, distal to the most posterior tooth on one side of the mandible, and, with the bristles directed downward, the gingival crevice and distal portion of the tooth crown should be swept thoroughly. This area is the most frequently neglected in brushing. The brush should then be applied to the buccal surface of this tooth and adjoining teeth which can be covered by the brush head, and with the bristles directed obliquely against the gingivae, pressure should be exerted downward and laterally, with the bristles held firmly in position, short rotary motions applied to the brush for 15 rotations. This cleanses the buccal surfaces of the teeth and stimulates the gingival tissues. This is continued until all of the buccal and labial surfaces of all of the mandibular teeth are covered.

The distal portion of the most posterior mandibular tooth on the opposite side is swept behind, and the brushing technique is continued over the lingual surfaces, routinely following the curve of the arch. A slight variation of brush application is necessary due to the arch curve. Instead of attempting to use the entire head of the brush, only the tip half is used. The same sequence of brushing is repeated on the upper arch.

It is generally recognized that brushing alone is inadequate, and supplementary aid is necessary for oral health. This is especially true in partially edentulous mouths where one or two teeth are positioned alone. Instruments are manufactured to hold a round toothpick point at an oblique angle so that gingival areas can be more advantageously cleansed, and interdental stimulation easily produced.

Routine and systematic coverage of the gingival surfaces of the teeth and soft tissue margins is made once daily. The toothpick is first softened by wetting, and the patient is told to visualize the teeth as fingernails, and to manicure them as one would use an orangewood stick. In this way, the critical gingival surfaces of the teeth are cleansed, and the gingival margins scrupulously cleansed and stimulated. Each tooth is given an equal amount of care, and both arches covered routinely, as in brushing.

DISCUSSION

The author strongly feels that closer cooperation and understanding between the periodontist and prosthodontist is essential for best possible results, and that every effort should be made to harmonize principles of each specialty in treatment, so that the patient will be more adequately served. While the prosthodontist is dependent on periodontal principles for best results, the reverse is equally true. A periodontally treated, partially edentulous mouth is not a completely treated mouth, and can only be considered a temporary success without a well-planned, scientifically made and inserted prosthetic appliance. Therefore, instead of a chasm of misunderstanding separating the two viewpoints of the two specialties, intelligent planning of treatment and an understanding of each others' problems should be of mutual aid to the practitioners as well as to the patients. This assures oral health for the patient, which is the ultimate objective of *all* dental treatment.

SUMMARY

1. A knowledge of oral anatomy and physiology is an essential for best periodontal and prosthetic treatment planning.

2. A clinical and radiographic examination, study casts, as well as health history of the patient, are essential before rational, periodontal treatment planning is possible.

3. Gingivectomy can be employed with satisfaction to increase clinical crown length of abutment teeth.

4. Well-planned and executed fixed splinting can frequently preserve key abutment teeth weakened by periodontal bone loss, and ensure patient comfort for extended periods.

5. Occulsal equilibration is necessary before construction of partial denture prosthesis, and should be carefully checked after insertion of the appliance.

6. Periodontal health is essential to successful partial denture prosthesis.

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641 DuPont Bldg.
Miami, Fla.

THE PRECISION DOWEL REST ATTACHMENT

FRED N. HARRIS, B.S., D.D.S.

Pasadena, Calif.

WE ARE ALWAYS alert for successful techniques to implement our work because of the many difficulties inherent in partial denture construction. Inasmuch as the precision attachment partial denture is, in a sense, the connecting link between fixed bridgework and full denture construction, its conception and application demand the finest skills involved in both extremes of prosthetic appliances.

The precision dowel rest attachment for partial dentures has been very satisfying from the viewpoints of mechanical efficiency, esthetics, and the psychology of the patient. This attachment was evolved quite directly from some of the best current fixed bridgework and full denture techniques. I am deeply indebted to Dr. Morris Thompson for his work in developing the attachment, and for teaching me its construction and use.

McCall and Hugel[1] have shown the importance to the patients' psychology of using partial dentures as a step between the dentulous state and the edentulous state in this way: "To be or not to be edentulous is a question that arises in the minds of patients when they suddenly realize they have only a few teeth left. The dread of the middle-aged person of suddenly becoming old, and the menacing fear of the younger people of having to go through life with a full denture becomes an emotional problem."

Although the use of the precision dowel rest attachment is admittedly limited, I have applied it repeatedly, and with success to several types of cases—the bilateral distal extension and the mesial extension and others. Properly designed and applied, the precision dowel rest attachment makes great strides toward the solution of five common problems of both distal and mesial extension cases.

THE PROBLEMS

The first problem is the abuse suffered by the anchor teeth. The point of contact between the metal of the denture's retainers and the surface of the anchor tooth is a troublesome source of caries.

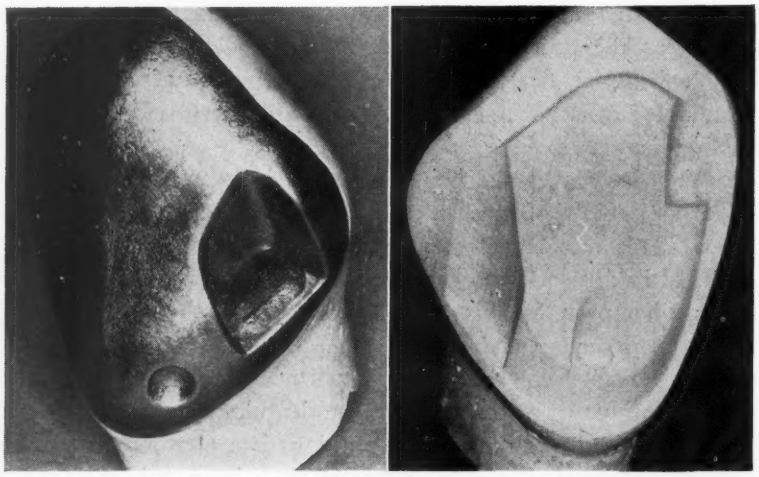
The second problem is that of stress. The pressures involved in the normal course of eating create a recurring stress on the abutment, through displacement of soft tissues. It is a rare instance in which the anchor teeth do not suffer unless stressbreaking appliances are used.

The third problem is one of hygiene. The denture and the abutment must be kept clean.

Presented before the American Denture Society at Chicago, Ill., Feb. 8, 1953.
Received for publication June 17, 1954.

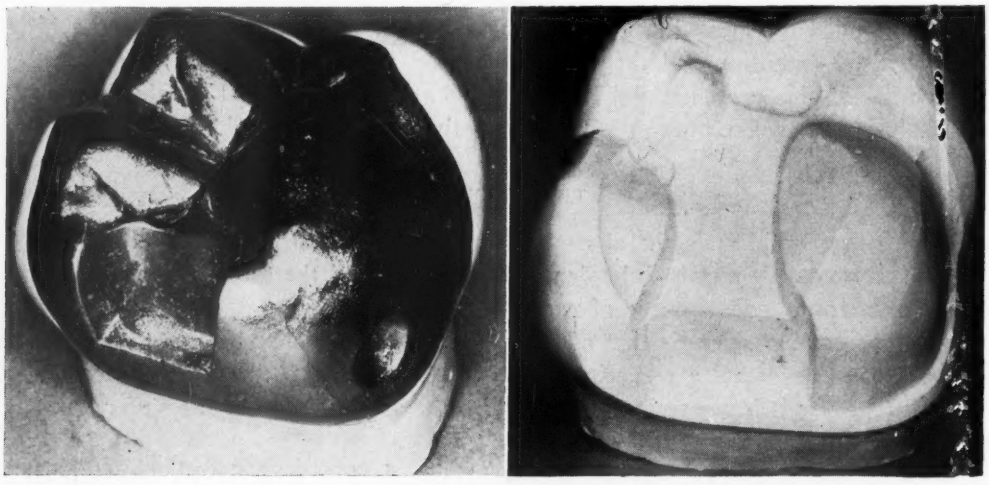
The fourth problem, and perhaps that which causes the greatest psychologic problem to the patient, is the unsightly show of gold.

The fifth problem is the need for an appliance to restore lost teeth and soft tissue (which so often happens as the result of traumatic injuries) particularly in the anterior part of the mouth. These situations are difficult to handle with fixed bridge work, but the precision dowel rest attachment in its mesial application seems to be one answer.



A. *B.*

Fig. 1.—*A*, The precision dowel rest attachment in a three-quarter crown. *B*, A preparation for the attachment.



A. *B.*

Fig. 2.—*A*, The precision dowel rest attachment in a molar restoration. *B*, The preparation of the tooth for attachment.

FUNCTION AND DESIGN OF THE ATTACHMENT

The abutment teeth are prepared to receive gold castings in which female dowel shapes are made as illustrated in Fig. 1. These abutment castings must be the strongest possible (Fig. 2). The full crown, three-quarter crown, Kennedy crown, the pin-ledge attachment, and other restorations of similar strength and permanence must be used. This abutment casting, whatever its type, must always involve the lingual surface of the anchor teeth. This is to accommodate a dimple, recessed in this surface. In the surface proximal to the edentulous space, the dowel-shaped recess is prepared in the wax pattern, and at the same time the dimple is cut. This dowel shape recess is prepared while in the wax in order to be sure that the several precision dowels will be parallel, or closely so, permitting the partial denture to seat, and also to be sure that there will be enough metal surrounding the female dowel shape in the abutment casting to lend the necessary support. It is also important that the dimple be cut at this time so that its placement and depth can be definitely established. In Fig. 3, we see the framework of the partial denture terminating in a retaining arm of dowel shape, which fits into the female dowel shape of the abutment casting, and over the dimple.

Fig. 3.—A partial denture with the dowel shape retaining arm and the spring arm with a boss to fit into the dimple in the abutment casting.

The retaining arm has a small boss which will fit into the dimple on the lingual surface of the abutment casting; it also has a dowel which fits into the recess on the surface proximal to the edentulous space. The resulting effect is that the retaining arm grips the abutment casting somewhat in the manner that a bowling ball is held by two fingers. The attachment is firm, yet can be made movable by properly altering the shape of the dowel.

The last important feature of the precision dowel rest attachment we call a spring, though it is not a spring in the ordinary sense of the word. Between the boss and the dimple (the two points of attachment at the terminus of the denture framework) a saw cut is made. This cut permits the finger spring to lift and seat when in place, locking the partial in situ.

To seat the attachment, pressure is exerted, the saw cut opens, the finger spring lifts permitting the boss on the retaining arm to engage the dimple on the abutment casting. The tendency of the finger spring to close from its ex-

tended position, like the resiliency of a spring, tends to lock the attachment into place. By varying the length of the cut, the degree of tension on the finger spring may be regulated.

TECHNIQUE

In making the precision dowel rest attachment, I have found the greatest success with the following method. I use the reversible hydrocolloid method, as described by Thompson[2, 3] in several articles, for making the master casts. From the master casts, the abutment castings are made. Then by the use of the usual duplicating technique, the master cast, containing the abutment castings, is duplicated. The usual method of waxing and casting is employed. Before fitting the dowel to the abutment casting, the saw cut must be made in the denture framework, as shown in Fig. 4.

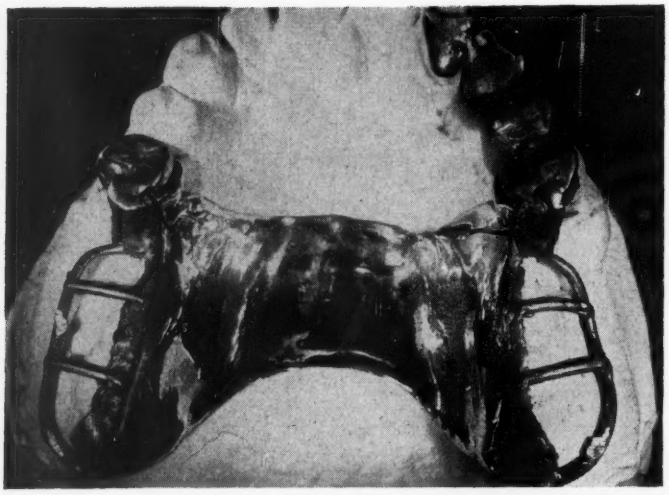


Fig. 4.—A partial denture framework with saw cuts to provide resiliency to the spring arm of the attachments.

APPLICATION OF PRINCIPLES

As you have seen, the attachment does not hold to the anchor tooth itself —rather, it holds to the abutment casting which will be permanently cemented into place in the tooth. The problem of caries in the anchor tooth is thus controlled by virtue of the fact that no part of the partial denture framework actually touches tooth structure.

The second problem was stress. The springlike effect of the finger spring which we create in the denture framework by the saw cut reduces the stress on the abutment tooth to a minimum. We call this attachment a stress-breaker, and for all practical purposes, we have found the attachment to relieve the anchor tooth of considerable stress. Its design directs the occlusal stress through the long axis of the tooth, in its proper direction.

Despite the fact that the appliance cannot be dislodged except in the reverse direction in which it has been placed, a certain amount of desirable "play" can be developed by altering the dowel shape. The dowel is cast to fit the dowel

Fig. 5.

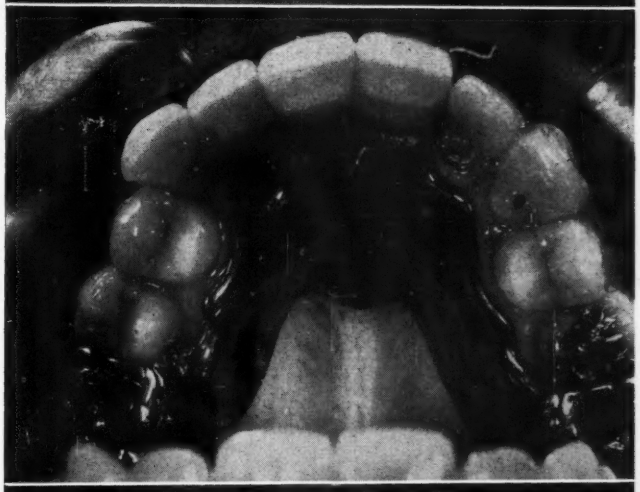


Fig. 6.

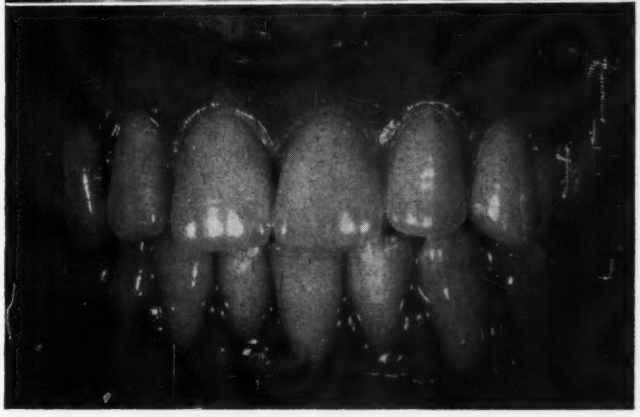


Fig. 7.

Fig. 5.—A typical situation which calls for the use of the precision dowel rest attachment. Anterior teeth and supporting structures have been lost.

Fig. 6.—Occlusal view of the restoration in place.

Fig. 7.—The completed restoration. Note that no gold is visible.

seat accurately and is never polished. The use of the steel brush wheel is recommended. To create the desirable play, the lower part of the dowel must be relieved by judicious grinding on the side opposite from the movement. This permits the dowel to rotate around an axis which lies between the stirrup and the center of the dimple, and between the center of the dimple and the stirrup of its reciprocal attachment in a two attachment partial denture, such as is found in a bilateral distal extension partial denture or a two abutment mesial extension partial denture. The stirrup is that wall of the abutment casting that forms the lower part of the seat of the dowel. Frictional or clutching stress on the abutment teeth is minimized during chewing. It is for this reason that we feel the attachment may be called a stress-breaker.

The problem of good hygiene is met by the conformation of the denture to the shape of the tissue surrounding the teeth. Few places are left in which food can be lodged, and the patient finds it easy to keep the denture clean.

The esthetic problem of a partial denture is a prime factor in the approval of the attachment by patients. Little gold shows, and the abutment teeth may be restored to, or kept in, natural contour. Further, since no metal of the partial denture actually touches tooth structure, caries is minimized. Abutment teeth are more easily preserved. Restoration of teeth of proper size and efficiency is a simple matter. Fig. 5 shows an example of the necessity for restoring teeth and lost supporting tissues in the anterior part of the mouth as the result of a traumatic injury. The mesial extension application of the precision dowel rest attachment can be used in these difficult situations. Fixed bridge work is contraindicated. Well-supported teeth in the posterior part of the mouth may be used as abutments as shown in Fig. 6.

The partial denture projecting forward from the abutments makes the necessary restoration of lost teeth and supporting structures as shown in Fig. 7.

SUMMARY

The precision dowel rest attachment retains a removable appliance to supply lost teeth satisfactorily with: (1) No contact of the appliance on tooth structure, (2) A stress-breaking effect, (3) A hygienic contour, (4) No gold exposed, and (5) The restoration of the supporting structures as well as the missing teeth.

Very accurate operative dentistry must be pursued. The strongest abutment castings possible must be used. Great care must be utilized in making the saw cut, as its length determines its springiness.

When all of the steps in construction are properly applied, an ideal partial denture can be made for the meticulous partial denture patient.

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386 E. Walnut St.
Pasadena, Calif.

STRESS BREAKERS WHICH AUTOMATICALLY RETURN THE SADDLE TO REST POSITION FOLLOWING DISPLACEMENT

Maxillary Distal Extension Partial Dentures

Allison G. James, D.D.S.

Beverly Hills, Calif.

A PREVIOUS ARTICLE[1] described the application, in mandibular partial dentures, of a principle of breaking stress between the saddle areas and the abutment teeth, which returns the saddle to rest position through inherent resiliency of the appliance itself, rather than through recovery of displaced soft tisues. This article will describe and illustrate a method which effects a similar result in the maxillary arch. This method has been in use much longer than the method described for the mandibular arch. While this method has proved the most satisfactory in supplying distal extension maxillary partial dentures, it must be granted, however, that the characteristics of the maxillary arch render the mechanical principle less effective than in the mandibular arch.

PRINCIPLE

The basic principle involved is that the portion of the appliance directly attaching to the abutment teeth, the anterior part of the palatal casting, shall be rigid, and with the minimum motion possible allowed between it and the abutments. The saddles will be attached to this rigid portion by a narrow isthmus in the saddle casting, as close as feasible to the midline of the palatal appliance. There is no connection other than this near-midline attachment between the saddles. Each distal extension saddle is to move freely and independently of the other. Recovery of the saddles following displacement by masticatory forces is effected through resiliency in the narrow isthmus of each of the separate saddle castings. Early failures, dating as far back as 1935, resulted from the insertion of a palatal bar between the saddles in a mistaken idea of strengthening the appliance. In 1946, the mechanical fallacy involved in the utilization of an attaching palatal bar (Fig. 1) between saddles was realized, and from that time the appliances were made with free ends (Fig. 2).

ABUTMENTS

Multiple abutments are used wherever possible, and castings with internal attachments are the method of choice. Methods of cavity preparation and interabutment attaching are identical to those previously described for mandibular partial dentures.[1]

Read before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 3, 1951.
Received for publication June 25, 1954.

ATTACHMENTS

Male attachments, slightly tapered and cast directly on the anterior portion of the palatal casting to fit receptacles cut in the abutments, are used in preference to the frictional type of precision attachments. Resistance to displacement is effected through positive locks, such as modified Neurohr latches and spring locks.

Fig. 1.

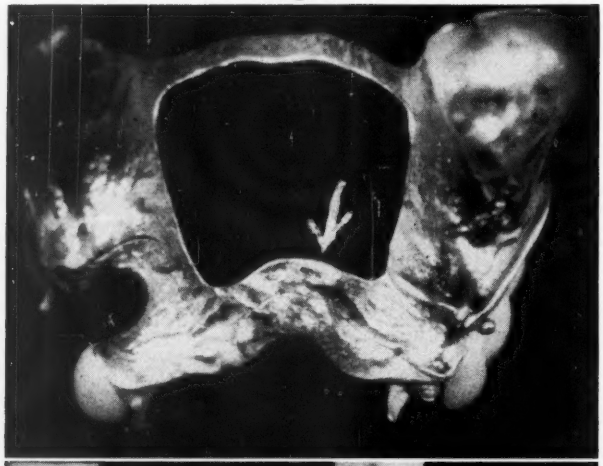


Fig. 2.

Fig. 1.—An early maxillary denture using spring resiliency of the metal for recovery. Saddles were attached together rigidly by the palatal bar. This denture had been worn thirteen years. Fracture occurred at point indicated by the arrow near the solder union of the distal extension section to the anterior tooth-attaching portion. Fractures had occurred at this same point previously.

Fig. 2.—The denture to replace the one shown in Fig. 1. It has been redesigned with individual freedom of the saddles. The same abutments were used. This denture has now been in use six years with complete satisfaction.

IMPRESSIONS

Reversible hydrocolloid is used for all impressions. The making of the die impressions as well as those for the master cast has been fully described previously.[1]

The paralleling of the attachments and the contouring of the latch springs has been previously described, as has been the making of the duplicate refractory casts.[1] Additional care should be used in blocking out all undercuts in the maxillary arch so that it will be possible to pour two refractory casts in this same impression.

WAXING AND CASTING

The previously contoured and polished latch wires are tacked in place firmly and thoroughly lubricated. Wax for the rigid casting is now applied to the refractory cast in the desired thickness—usually two thicknesses of 28 gauge wax is desirable—and the rugae are reproduced with blue inlay wax on the lingual surface of the palatal portion. The distal of this portion forms the truss and the male attachment. A very important detail in this rigid casting is the extension distally of a lip continuation of the male attachment. This is carved into

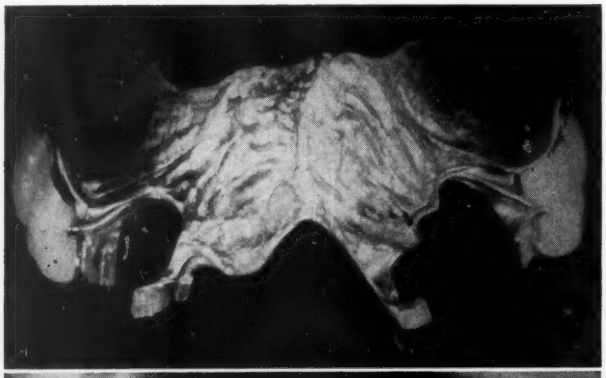
Fig. 3.—The distal extension saddle portions are waxed directly to the polished edge of the rigid gold casting which is in place on the refractory cast.

direct occlusion with the opposing mandibular teeth. This lip will cover the split between the free-moving saddle and the rigid portion of the appliance, preventing food impaction in this region. The distal surface of this portion of the rigid palatal casting and attachment is made smooth and parallel to the vertical deflecting line of the saddle, with a vertical ridge or bead which will act as a guide track for the distal extension saddle as it is displaced by masticatory pressures.[1] The posterior border of this rigid section, as it approaches the

midline, is reduced to allow the desired width of the isthmus of the second casting. Just short of the midline, it is turned in a smooth bulbous curve which brings the posterior border at the midline to the finishing line desired (Fig. 3). This posterior border is cut square and smooth, with the exception of the center portion which forms the posterior border of the denture, and which will be slightly beaded according to general practice.

This completed palatal casting with the male attachments is now returned to the master cast and checked for accuracy, and the occlusion of the distal lips

Fig. 4.



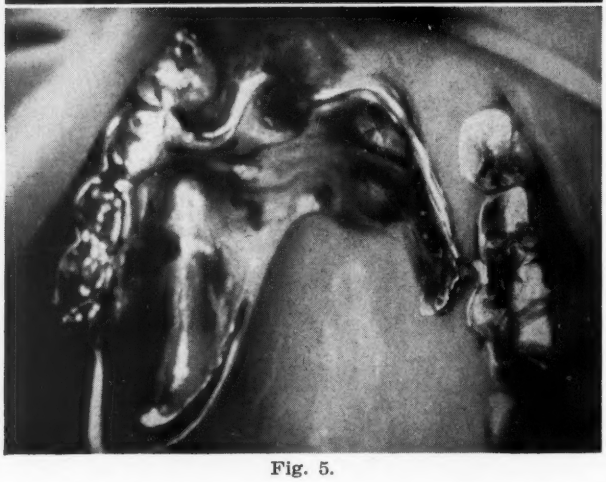


Fig. 5.

Fig. 4.—A bilateral distal extension denture with anterior stabilizing attachments.
Fig. 5.—A unilateral distal extension denture in the mouth after one year of wear. Note the junction line between the parts is imperceptible.

is perfected. The posterior border is now highly polished, and the casting is placed in position on the second refractory cast. If any inaccuracy in this second refractory cast is found which prevents the rigid casting from going to place correctly, the casting should be replaced on the master cast and a new duplication made. Waxing and casting the saddle frameworks, or saddles, dependent upon whether diatoric teeth or tube teeth are to be used, directly against the highly polished surface of the first casting has been found to give the best result. It

has been found that they will not fuse if the first casting is sufficiently polished. Upon the removal of the flags over the original casting, if any occur, the parts may be easily separated. This method gives a sharper, tighter joint than is likely to be achieved by casting to a refractory cast which duplicates the previously made gold portion.

The two castings are finished down, polished, and assembled on the master cast, with the latch wires in place. Soldering of the saddle portions to the rigid casting is done only in the bulbous areas adjacent to the midline. Twenty-two karat solder is used, and, at the same time, the latch wires may be soldered in place with the same karat of solder. The metal assembly is polished, heat treated, and re-polished as necessary, to complete it.

Fig. 6.

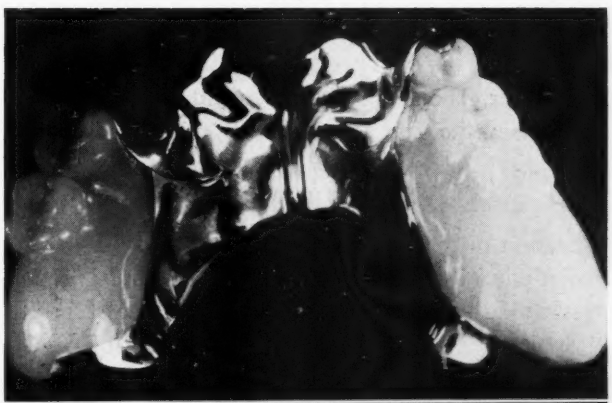


Fig. 7.

Fig. 6.—A bilateral distal extension denture using acrylic resin saddles and diatoric teeth. This has been found preferable because of the decreased weight.

Fig. 7.—The right side of the maxillary denture shown in Fig. 6. The patient is also wearing a mandibular distal extension denture of the type designed on the same principle.

DISCUSSION

Distal extension maxillary partial dentures of this type, which have been used over a number of years, have shown no settling of the saddle areas at the distal portions, and no consequent soreness nor inflamed areas at that point (Figs. 4 to 7). It is obvious that from the mechanical standpoint, this method of construction will be more successful in the flatter type of maxillary vaults.

It is least efficient in the high vault type, but even in these it appears to give the best results of any method I have used to date. Success of such a restoration is dependent upon good dense castings, and completely nonporous solder joints. Out of a large number inspected in the past six years, only two have required repair at the central solder joint; in one instance, it was due to a very poor porous soldering union, and, in the other, the first casting was found to have considerable porosity at the critical point. Unfortunately, this had not been detected at the time of construction. In each case, repair was satisfactorily effected by contouring 14 gauge gold orthodontic wire to the shape of the rugae and soldering it to the lingual surface of the palatal portion of the appliance. In neither instance did the patient mention any sense of obstruction or note the increased thickness of the denture. This probably would not have been true if the thickness existed from the very beginning when the patient had to accustom himself to a foreign body in his mouth.

The earlier-designed maxillary dentures, in which the saddles were connected by a palatal bar, showed rather frequent breakage at the torque point where the distal extension portion attached to the anterior tooth-supported section.

SUMMARY

1. The application of a principle of self-recovering stress breakers to maxillary distal extension partial dentures has been described. Distal extension saddles displaced by masticatory forces are returned to their rest positions through the resiliency of the appliance, rather than by the resiliency of displaced tissue in the saddle-bearing areas.

2. Distal extension saddles are independently sprung so that stresses applied to one side do not result in a consequent displacement, or tendency to displacement, on the other side.

3. Flexibility may be increased by reducing the thickness of the resilient (isthmus) portion of the appliance.

4. The use of multiple abutments, rigidly inter-attached, preserves their relationship, and reduces to a minimum the tendency to periodontal destruction.

5. Patient reports of increased comfort and the obvious improvement of tissue tone indicate the effectiveness of this method of stress-breaking.

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409 North Camden Drive
Beverly Hills, Calif.

PONTICS IN FIXED PARTIAL DENTURES

HERBERT R. BOYD, JR., D.D.S.*

School of Dentistry, Medical College of Virginia, Richmond, Va.

A PONTIC may be defined as an artificial substitute which serves as a replacement for a missing tooth of the normal dentition. It occupies the edentulous space and is connected to the retainers of the fixed partial denture.[1] It is constructed to ensure proper function, cosmetics, and sanitation and to be reasonably comfortable to the oral tissues.[2] Strictly speaking, the word pontic means the entire substitute for the missing tooth whether it be gold and porcelain, gold and acrylic resin, or all gold.

Today, pontics constructed of gold, porcelain, acrylic resin, or a combination of gold and porcelain or gold and acrylic resin are a far cry from those used in early times when the teeth of animals, bone, bits of ivory, gold, and other metals were used as fixed partial denture pontics.[3]

The most popular pontic now in use is the combination of gold and porcelain.[2] The gold portion is that part of the pontic that gives rigidity and strength to the restoration while the porcelain acts as a veneer to mask the gold. Since it is well tolerated, porcelain is usually placed in contact with the gingival tissues. Acrylic resins are rapidly becoming popular, being used in the same manner as porcelain. Only time will tell whether or not they will completely replace porcelain. Before any pontic is selected, consideration must be given to the requirements of the edentulous area where it is to be used. There are three over-all types of pontics: saddle, convex, and ridge lap, classified according to their relationship to the ridge. One must first choose the type before selecting the individual pontic.

SELECTION OF PONTICS

It is essential to consider collectively all the factors entering into the selection of a particular pontic. Among these factors the most important are: cosmetics, strength, cleanliness, sanitation, and restoration of proper function. The selection may also be influenced by the number of teeth to be replaced and the design of the fixed restoration. Probably the most important of these factors is the restoration of proper function in such a manner that good oral health and hygiene are easily maintained.[2] In order to do this, the pontic must be so constructed and contoured that during mastication the food will scour and stimulate the gingival tissues as would be the case with a normal tooth. The porcelain should present no sharp angles. It is generally agreed that well-glazed porcelain is the least irritating of all restorative materials, and, it possesses high cosmetic

Received for publication July 17, 1954.

*Instructor, Crown and Bridge Prosthodontics.

qualities, a combination of porcelain and gold is considered best. The pontic should cover only a minimum of firm immovable tissue. The embrasures should be opened wide where possible to facilitate the use of dental floss and toothbrush. In some instances, the pontic should be about one third narrower buccolingually than the tooth being replaced, to reduce the amount of stress placed on the abutment teeth.[1]

The consideration of cosmetics also plays an important part in the selection of a fixed partial denture pontic, especially in the anterior segment. The selection of the proper shade is essential; the alignment, the shape, the contours, and the reproduction of irregularities common to the natural teeth also play a major role in the cosmetics of the finished restoration. Well-glazed porcelain is not only desirable from a cosmetic standpoint, but also compatible with soft tissues. It is self-cleansing or readily cleansible.[4] Naturally, the elimination of the unsightly display of gold plays a large part in the cosmetics of the finished restoration.

The design of the fixed partial denture plays a major role in the selection of the proper pontic. Often it is very difficult to repair the porcelain portion of a pontic without removing the entire fixed partial denture, and this factor should be considered in the selection and design of the artificial substitute. Careful consideration in the selection of a fixed partial denture pontic can do much to facilitate its replacement in the mouth in case of fracture.

In the following discussion of the various pontics no new ideas are being presented. The purpose of this article is to compile information gathered from various sources. In some instances it will be necessary to use trade names as some pontics cannot be identified otherwise. Other pontics in use at the present time have been omitted, but it is felt that they are modifications of one or more of the following artificial substitutes. Since the word pontic is used very loosely, it is necessary for the purpose of clarification in this article to use the word to mean only the porcelain or acrylic resin portion of the artificial substitute.

ANTERIOR PONTICS

1. *Trupontic.*—The two types of anterior Trupontics available, the saddle (Fig. 1) and cone types (Fig. 2), are named according to the shape of their gingival surface. The saddle type is the most common and is used in those patients where the alveolar ridges are completely healed and where there is adequate intermaxillary space. The cone type is seldom used, and is indicated only following a recent extraction of a single tooth.[5] The concave gingival area of the saddle-type Trupontic is more conducive to regeneration of tissues to their normal curvature than is the cone type which fits into the alveolar socket.

A Trupontic is comfortable to the patient due to the similarity of its contour to that of a natural tooth. It meets the requirements of strength, cosmetics, tissue tolerance, and ease of repair.[1]

Trupontics are interchangeable pontics that depend upon a slot in the porcelain for their retention. They are available in many molds for anterior and posterior

replacements. In the opinion of many, the Trupontic is the one of choice whenever the intermaxillary space is sufficient for its use.

2. *Pin Pontic* (Fig. 3).—The pin pontic is so designed that it meets many of the requirements of an ideal substitute in that it is comfortable to the patient and it has good tissue tolerance, function, and sanitation. It has an all-porcelain incisal edge and gingival shoulder, and the cosmetics of this replacement is excellent.[6] The pin pontic is not supplied in the cone-shaped gingival surface, but it can be modified easily by the addition of porcelain to form the required convex surface. It can be used in patients where the incisogingival space is short and where a Trupontic cannot be used satisfactorily.

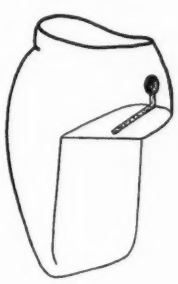


Fig. 1.

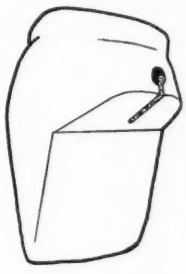


Fig. 2.

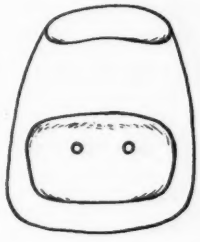


Fig. 3.

Fig. 1.—Saddle type anterior Trupontic.
Fig. 2.—Cone type anterior Trupontic.
Fig. 3.—Anterior pin pontic.

From the lingual aspect this pontic has two projections, a gingival ledge and an incisal shoulder. Between these two projections are two pins parallel to the gingival ledge.[6] This is also an interchangeable pontic and can be replaced in case of fracture. In patients presenting an unfavorable occlusal relationship, a gold incisal edge is indicated. In order to do this, it is necessary to remove the incisal shoulder and place a lingual bevel on the incisal edge to permit gold protection.

Many other modifications of this pontic are possible, depending upon the requirements of the particular patient and the ingenuity of the operator.

3. *Modified All-Porcelain Pontic* (Fig. 4).—The modified all-porcelain pontic is a porcelain tooth with a dowel hole and is usually referred to as a tube tooth. It is used where the occlusal relations are very favorable, as it is likely to fracture and replacement is difficult.

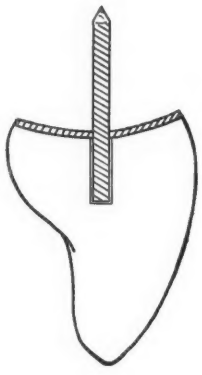
This all-porcelain pontic is cemented to the gold casting which is made for the entire gingival area, including the dowel. Due to the presence of gold in contact with the gingival tissues, it is not conducive to good oral hygiene.

4. *Reinforced Porcelain or Acrylic Resin Pontic* (Fig. 5).—Whether a reinforced porcelain or a reinforced acrylic resin pontic is used depends entirely upon the particular case and the personal preference of the operator. The technical procedures vary since platinum is used in conjunction with porcelain, and gold is used with acrylic resins.

In the construction of a reinforced acrylic resin pontic for an acrylic bridge, plate gold is burnished over both abutment preparations or castings are made to form gold cores. These two cores are soldered to a connecting bar which is any shape other than round to prevent the acrylic resin pontics from rotating on it. Acrylic resin is processed over the bar and cores to form the acrylic resin substitutes for the missing teeth.[7]

5. *Modified Pin Facing* (Fig. 6).—To classify the modified pin facing as an anterior saddle-type pontic, it must be modified by the addition of low-fusing porcelain to a pin facing to form the saddle area. It has good cosmetics, sanitation, and tissue tolerance; and it is comfortable to the patient. The advantage pertaining to the use of this type of pontic is that it can be used in patients with

Fig. 4.



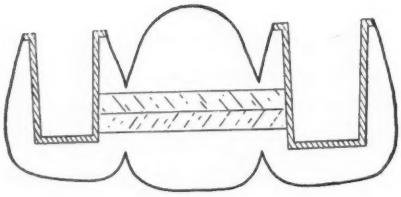


Fig. 5.

Fig. 6.

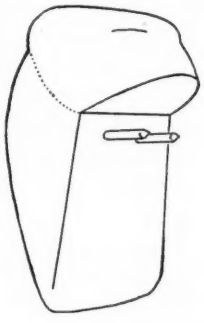


Fig. 7.

Fig. 4.—A modified all-porcelain pontic showing a dowel and casting for the gingival area to which the pontic is cemented.

Fig. 5.—Reinforced acrylic resin pontic. Acrylic resin is processed over the copings and the connecting bar.

Fig. 6.—Modified pin facing showing the addition of porcelain to form the saddle area.

Fig. 7.—Regular interchangeable facing.

a small occlusogingival space, where cosmetics is important and where a Trupontic cannot be used. Its disadvantage lies in the fact that it takes additional time to construct; and, if fractured, it is very difficult to replace.

A shelf of porcelain of the proper shade is added to the gingival area of a pin facing. The gold portion may be soldered or cast. In the soldered method, plate gold is burnished over the lingual surface, allowing the pins to protrude.

The pontic is positioned on the refractory investment cast, and secured with a second mix of refractory investment. Solder is added to the plate gold until the lingual contour is built up sufficiently that it can be carved to proper anatomic form, and at the same time the pontic is joined to the retainers.[8] When cast backings are preferred, graphite points are used in the pinholes of the wax pattern to ensure smooth casting around these holes.

A flat pin facing, which has two flat pins, could be used instead of a round pin facing.[9] In some instances, a further modification may be a bevel on the incisal edge to shorten the tooth and afford protection to the porcelain.

6. *Interchangeable Facings.*—Four different interchangeable facings of the ridge lap type are available. Their main advantage lies in the fact that their correct length is obtained by grinding the ridge lap and not the incisal edge so that they are replaced easily in the mouth in event of fracture. They all have a standardized post hole or slot on the lingual surface for attachment to an interchangeable backing of the corresponding type. The four are:

A. *Regular (without collar)* (Fig. 7): A regular facing has a smooth labial surface with no collar or pronounced developmental lobes. From the lingual aspect, it is perfectly flat with only a post hole or slot for retention.[5] It is not too widely used today due to the more translucent porcelain available in other interchangeable facings of the ridge lap type. It may be obtained in many molds and is used primarily for replacement of broken facings.[10]

B. *Trubyte facing (with collar)* (Fig. 8): The distinguishing characteristic of the Trubyte facing is the definite gingival collar line on the labial surface. Mechanically, it is the same facing as the regular facing.[5] Its use today has also declined due to the more translucent shades of porcelain available in other facings. These facings are manufactured only in upper and lower anterior molds.

C. *Porcelain biting edge facing* (Fig. 9): The porcelain biting edge facing is used to obtain the ultimate in cosmetics due to the elimination of the display of gold. It has a lingual incisal area of porcelain which improves cosmetics but makes it more susceptible to fracture. It is for this reason that its use is limited to selected cases. The flat lingual surface starts at the ridge lap and ends about 2.5 mm. from the incisal edge. While this feature does prevent the incisal 2.5 mm. from having any gold protection, it is constructed so that the porcelain has greater bulk in this area. It is of prime importance that the facing fit its backing accurately. The backing is a special type designed to fit the lingual incisal shoulder. At the present time this facing is available in upper and lower anterior molds.[8] Within the last few years there has become available an acrylic resin biting edge facing.[11] Its use depends upon the preference of the individual for porcelain or acrylic resin facings.

D. *Flatback facing* (Fig. 10): The new translucent shades of the flatback facing have probably made it the most popular type of interchangeable facing in use today for the replacement of missing anterior teeth. It has characterized

markings on the labial surface which reflect light, making it more pleasing to the eye.[5] This facing is available in many upper and lower anterior molds. Flatback facings can be used with either casting or soldering procedures.

7. *Pin Facings* (Fig. 11).—Anatomically, a pin facing is similar to the interchangeable facing with the labial collar; but, instead of having a slot or post hole for retention, it has two pins on the flat lingual surface.[8]

After the facing has been ground to conform to the requirements of the edentulous area, the gold portion of the pontic may be cast or soldered. The advantages of pin facings are that they can be used for patients with short occlusogingival spaces where other types of pontics will not have sufficient retention, and that the incisal edge may be beveled for gold protection. Among their disadvantages are their poor shades, and the difficulty encountered in replacing them in the event of fracture.

Fig. 8.

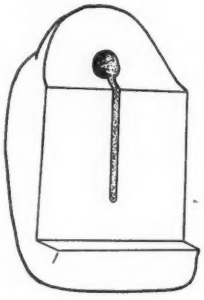


Fig. 9.

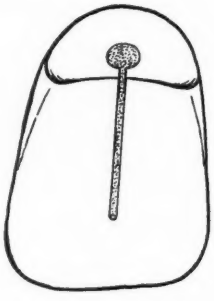


Fig. 10.

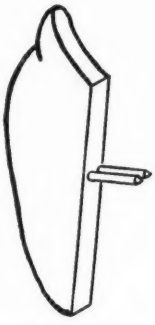


Fig. 11.

Fig. 8.—Trubyte interchangeable facing. Note the gingival collar.
Fig. 9.—Interchangeable porcelain biting edge facing.
Fig. 10.—Flatback interchangeable facing.
Fig. 11.—Anterior pin facing.

Instead of using a pin facing with two round pointed pins, some operators may prefer to use either a round blunt pin facing or a flat pin facing.[12]

POSTERIOR PONTICS

1. *Sanitary Pontic* (Fig. 12).—The sanitary pontic is the most popular type of mandibular posterior pontic in use at the present time. It is never used in a cosmetic area, and it is easily adapted to the requirements of an edentulous space with a minimum amount of grinding.[5]

When the reduction of porcelain has been completed, the occlusal outline of this pontic represents the outline of a normal bicuspid or molar in its middle third. The gingival portion is convex in all directions. From the buccal aspect, the occlusal surface of this pontic should be parallel with the plane of the occlusal surfaces of the mandibular arch of teeth.

It is available in three shades, light, medium, and dark, and in a number of bicuspid and molar molds.[13]

2. *Inverted Interchangeable Facing* (Fig. 13).—The inverted interchangeable facing is a modification of an interchangeable facing to resemble a sanitary pontic. Its only justification might be that less grinding may be necessary when short occlusogingival spaces exist than would be necessary with a sanitary pontic. This facing is positioned in such a way that the labial surface is in contact with the alveolar ridge and with the incisal edge toward the buccal. The facing is generally convex to resemble that of a sanitary pontic.[1]

3. *All-Gold Pontic* (Fig. 14).—An all-gold replacement is used only where a combination of gold and porcelain cannot be used because of inadequate occlusogingival space. Convex in all directions, it is similar in shape to the sanitary pontic.[1] Its use is limited to the mandibular arch. Its main disadvantage lies in the fact that gold approximates the gingival tissues. This is a condition that does not promote good oral hygiene.

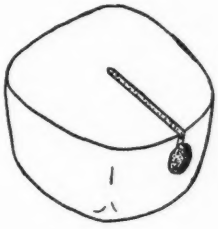


Fig. 12.

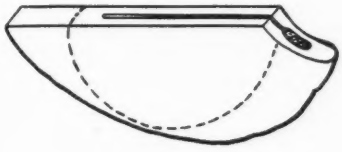


Fig. 13.

Fig. 12.—Sanitary pontic.
Fig. 13.—Inverted interchangeable facing, showing how a convex pontic could be made.

4. *Modified All-Porcelain or Acrylic Resin Pontic.*—A modified all-porcelain or acrylic resin pontic is a porcelain[13] or acrylic resin[11] pontic with a dowel hole for retention and is referred to as a tube tooth. It is usually used in the construction of removable partial dentures. In order to use this pontic in a fixed partial denture, it can be modified by making a three-quarter crown preparation on the porcelain or acrylic resin tube tooth. Then a gold casting is made for this preparation. This pontic is seldom used because it is very difficult to repair in case of fracture. It is possible to use a denture tooth or a tube tooth with or without a post hole and to make various modifications to suit the requirements and cosmetics of the particular patient. There are many modifications of this pontic.

5. *Trupontic* (Fig. 15).—Mechanically, the Trupontic is the same pontic discussed previously under anterior pontics. The success of a posterior Trupontic depends largely upon how it is adapted to the alveolar ridge. It should saddle a minimum of immovable tissue and must not exert any pressure on the ridge. The entire buccal surface and gingival area is of porcelain, with a gold occlusal surface which makes it an ideal pontic. This is one of the most widely used posterior pontics.

6. *Saddle-Type Pin Pontic* (Fig. 16).—The saddle-type pin pontic has two lingual pins and is made by grinding the incisal edge of an anterior pin pontic in order that it can be adapted for use as a posterior pontic.[8] The occlusal and lingual surfaces are of gold, and porcelain is in contact with the tissues. The incisal tip of the pontic is reduced to protect the porcelain from the load of mastication. In the event of fracture it is very difficult to replace.

Fig. 14.

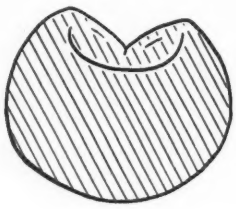


Fig. 15.

Fig. 16.

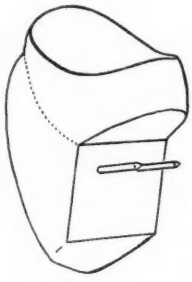


Fig. 17.

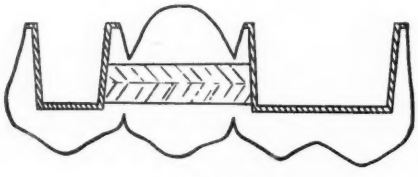


Fig. 18.

Fig. 14.—An all-gold pontic.
Fig. 15.—A posterior Trupontic.
Fig. 16.—Saddle-type pin pontic illustrating how an anterior pin pontic may be adapted for use in the posterior region. Shown in the illustration is a gold casting for this pontic.
Fig. 17.—Modified pin facing showing the addition of porcelain to a regular pin facing.
Fig. 18.—Reinforced acrylic resin pontic. Acrylic resin is processed over the copings and connecting bar.

7. *Modified Pin Facing* (Fig. 17).—A modified pin facing is made by adding porcelain to the gingival area of a regular pin facing.[14] In case of fracture it is difficult to replace. A flat pin facing could be used instead of a round pin facing.[9]

8. *Reinforced Porcelain or Acrylic Resin Pontic* (Fig. 18).—A reinforced porcelain or acrylic resin pontic is a highly cosmetic replacement and is used

in conjunction with a porcelain or an acrylic resin bridge. When using porcelain, it is essential that an iridioplatinum frame be used on which the porcelain is added.

Acrylic resin presents no problems since it can be processed on any suitable type of bar or framework.

9. *All-Porcelain Cusp Posterior Pontic* (Fig. 19).—The all-porcelain cusp posterior pontic is primarily indicated for posterior replacements where cosmetics is very important and where there is sufficient space between the ridge and opposing teeth.[5] It is an interchangeable pontic available in many ordinary and short bite molds for bicuspid and molar replacements.[12] The short bite molds are narrower buccolingually and have a smaller post hole than the ordinary mold. Tissue tolerance is rather poor since metal is in contact with the alveolar ridge.

Fig. 19. Fig. 20.

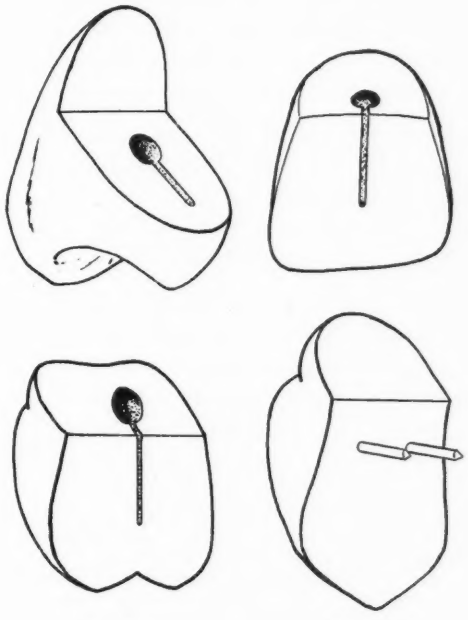


Fig. 21. Fig. 22.

Fig. 19.—An all-porcelain cusp posterior pontic.
Fig. 20. Anterior interchangeable facing.
Fig. 21.—Posterior interchangeable facing.
Fig. 22.—Posterior pin facing.

In an effort to obtain the maximum in cosmetics the all-porcelain cusp posterior pontic is designed in such a way that the entire buccal and occlusal surfaces consist entirely of porcelain.

10. *Anterior Interchangeable Facings* (Fig. 20).—In some instances, anterior interchangeable facings are used in the posterior region because they more nearly meet the requirements of the occlusogingival space. For example, since the maxillary cuspid facings are much thinner than the bicuspid facings, they may be used in the bicuspid area to an advantage; or central incisor facings may be

used as molars by the addition of a buccal groove. Some individuals may prefer to use an acrylic interchangeable facing.

11. *Posterior Interchangeable Facings* (Fig. 21).—A posterior interchangeable facing is a regular facing for a bicuspid or molar replacement that is used where the occlusogingival space is small and where cosmetics is important.[5, 10] When a posterior interchangeable facing is used, a food trap is formed between the gingival area of the pontic and the alveolar ridge. This is true of any interchangeable facing of the ridge lap type.

12. *Pin Facings* (Fig. 22).—Pin facings may be used where a very short occlusoalveolar space exists, and the use of an interchangeable facing may be contraindicated. They are available in either flat or round pins.[9]

CONCLUSIONS

Apparently a great deal of confusion exists today in the minds of many practitioners of crown and bridge prosthodontics relative to the type of porcelain pontics available for the replacement of missing teeth and the various indications of their use. At the present time there are many different pontics on the market. For some patients, one pontic may not have any advantage over another, and the choice is a matter of preference with the operator.

Although no pontic can be considered absolutely ideal, we should strive to select the one that fulfills the greatest number of requirements for health, strength, cosmetics, and function.

With the use of the pontics available, and some ingenuity on the part of the operator, any number of modifications are possible. During the past decades many improvements, both mechanical and cosmetic, have been developed. It is hoped that in the future further improvements will overcome our present difficulties.

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521 North Eleventh St.,
Richmond, Va.

RESTORATIONS MADE OF PORCELAIN BAKED ON GOLD

A. H. Woolson, D.D.S.

Spokane, Wash.

SINGLE CROWNS

THE tooth is prepared in the same manner as for a porcelain jacket crown. A shoulderless preparation is indicated for young persons because of the immature development of their teeth.

An impression and a die are made. A matrix of 24 karat, 45 gauge C.P. gold plate is made to fit the die. The matrix is roughened or punctured 1.5 to 2.0 mm. width next to the shoulder.

Apco 1,875° F. porcelain is baked on the coping. After the porcelain is fired, the matrix is removed, except for the small collar of gold at the shoulder.

PORCELAIN-FACED CAST GOLD CROWNS

A wax pattern for the gold crown is made in the usual manner. It is shaped as an open-faced crown with a thin layer of wax covering the die back of the opening and an ample undercut for locking the porcelain facing in position. The crown is cast in an alloy of 24 karat C.P. gold and 10 per cent platinum. Palladium alloys are not satisfactory. The recessed face of the casting should be thin and roughened, and the margins of the recess well undercut.

A matrix of 24 karat, 50 gauge C.P. gold plate is swaged into the recessed face of the casting. The margins of the matrix must be well adapted.

The margins only of the matrix are covered with Apco 1,875° F. porcelain, and this is baked in a porcelain furnace. A thin coat of Apco Opaque porcelain can be used if necessary. The contour of the facing is built up in subsequent firings. Generally, three bakes are needed to complete the facing. All pieces of the restoration can be removed from the furnace while it is at the firing temperature, without danger.

The use of 24 karat gold plate between the casting and the porcelain seems to be the secret of success.

After the porcelain is baked, the crown can be soldered to by the ordinary investing and soldering technique. The restoration may be used as an abutment for fixed bridgework, or for a precision attachment in removable partial dentures. This makes it a valuable restoration.

809 Paulsen Medical and Dental Bldg.
Spokane, Wash.

Presented as a table clinic at the meeting of the Pacific Coast Society of Prosthodontists in Seattle, May 30, 1954.

Received for publication May 30, 1954.

AN APPLIANCE FOR REGAINING AND MAINTAINING FIRST MOLAR SPACES

P. W. Herrick, D.D.S.*

College of Dentistry, State University of Iowa, Iowa City, Iowa

THAT DENTISTRY is making progress as a protector of health is shown by the number of healthy teeth in the mouths of those who use its many services. Progress is being achieved partly because the dentist makes an increasingly more adequate evaluation of the mouth conditions and thus is able to render better dental health service to patients. It is being achieved also because the dentist is more frequently able to guide a patient from an early age, and follow through on his treatment plans over a larger segment of the patient's life span. As a result, we are working in an era of broader dentist-patient relationship, more effective education, and more sound dental health understanding.

The dentist's part in this progress is very important, for happy is the patient who knows that his dentist is using every facility at his command to produce and protect a healthy mouth condition for him. We know that health is a basic requisite for happy living, and in this article I will discuss a dental appliance which, if used with good judgment, will aid in maintaining or regaining a healthy mouth condition.

Every dentist has seen patients around the age of 12 to 16 years who have lost, or are about to lose, an all-important lower first molar tooth. The need of proper treatment planning is always important, but it is more important for these patients who are at an age that governs so much the condition of their future dental health.

Much has been accomplished for our younger patients by making space maintainers for lost deciduous teeth, and thereby holding open the space so that the permanent teeth can erupt with ease in their proper positions. In contrast, many people around 12 to 16 years of age escape similar treatment for lost first molars, and, when they are seen by the dentist later, the second molar and the developing unerupted third molar are pushing forward with a mesial tilt toward the edentulous space and not bodily in an upright axis position. Fortunately, considerable has been written about the causes of the loss of the permanent first molars. This fact has helped to reduce the total number lost, but there are far too many who do not appreciate the importance this "keystone tooth" has on the facial growth, the occlusion, and the temporomandibular joint.

True, under the experienced care of an orthodontist at the age from twelve to sixteen, this space can be closed with the two molars being carefully guided into

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Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 7, 1954.

Received for publication March 16, 1954.

*Associate Professor in Crown and Bridge.

the edentulous space—guided so that the mesial surface of the second molar will contact the distal surface of the second bicuspid. Over a period of years the roentgenogram will reveal no pathosis as a result of this action. Many dentists, however, do not consider the resulting occlusion to be the ideal. Perhaps this point could be considered the deciding factor that would influence one to maintain this space during the remainder of the facial growth period, so that after the growth had ceased, the space could be restored with a fixed prosthesis, and thus the occlusion could be constructed to as near the ideal as possible.

When the first molar is lost before the second molar has erupted, the second molar may drift mesially with a slight tilt, eventually close the space rather gracefully, and present a fairly good contact with the second bicuspid. It seems more usual, however, to find a mesial tipping and shifting of the second molar which makes a poor contact, if any at all, with the bicuspid, and the resulting occlusion is further from that which is desired than ever. To add to the severity of this condition, there is formed a sort of a food trap which frequently results in a breakdown of the periodontal tissues in the area. The important factor in these cases is that the occlusion with the opposing teeth has been disturbed so that proper intercuspation of the cusps was difficult, if not impossible.

The maintaining and the necessary readjusting of drifted teeth, in order to bring the involved teeth back to as nearly normal a position as possible, has been a most interesting and pleasing procedure. It has been done with a more complete recognition of the biologic factors in bridge construction.

We are required to make crown and bridge restorations which function primarily to correct an abnormal oral condition. The loss of one tooth decreases masticating efficiency, and, as time goes on, the inefficiency increases unless restorative and preventive measures are employed. This inefficiency is represented by the drifting of the teeth toward the edentulous space, the opening of adjacent contact points, extruding of the opposing tooth, and finally, the loss of vertical dimension presenting a predisposition to a local periodontal pathosis.

Teeth that have drifted add difficulty to the fabrication of a posterior bridge. Many times we have had to resort to excessive cutting of tooth tissue to parallel the abutment preparations, which resulted in endangering the pulp. Also, abnormal axial inclination of the teeth has resulted in destruction of the periodontal tissues because the masticatory stresses were not carried properly.

When these patients are seen a long time after the date of extraction, the drifting and tilting of the teeth has usually progressed to such an extent that no fixed prosthesis should be constructed without first attempting to reopen the space and to bring the abutment teeth back into alignment. If the drifted teeth have rotated as well as tipped, it adds to the complexity of getting the teeth back into alignment. If however, the tooth movement has been a simple tilting, a simple appliance might be used to make the correction.

The appliance to be described has the additional advantage that it can be easily converted into a space maintainer after it has repositioned the drifted teeth. Thus for those young patients, where space has been lost and it is desirable to regain and hold space, or in any condition where a holding period is desired, its use can be recommended. The appliance was conceived with the idea

of repositioning teeth that have tipped and drifted into an edentulous space, partially closing it. It can be used with good results in many places, but it is of greatest value for the patient who has lost the lower first molar early and has had no subsequent treatment. If the drifted teeth are moved to a more normal position, a bridge can be fabricated to conform to established biologic principles, and thus eliminate many predisposing causes of local periodontal diseases.

CONSTRUCTION OF THE APPLIANCE

A stone cast is made from a full impression. The clasps and activator loops are made of 0.025 orthodontic wire. Two pieces of the wire about 3½ or 4 inches in length (long enough to make one side of each clasp and the large U-shaped spring activator) are cut.

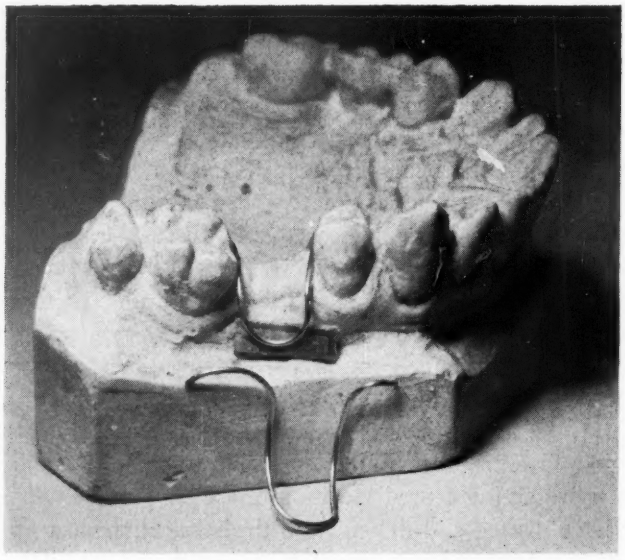

Fig. 1.—Orthodontic wires are adapted to form the clasps and activating loops.

One end of a piece of this wire is formed into half a circumferential clasp that fits against the buccal surface of the anterior abutment tooth. The wire is then bent to cross the ridge toward the palate or lingual side of the ridge close to the distal surface of the anterior abutment tooth. It is extended toward the hard palate or lingual side of the ridge far enough to form a U-shaped end. The wire is then bent back across the ridge close to the mesial surface of the posterior abutment tooth, and the buccal half of the circumferential clasp for the posterior abutment tooth is formed. The unused portion of the wire is cut off, and the buccal portions of the wire are adapted into the desirable undercuts on the abutment teeth (Fig. 1).

The second piece of the orthodontic wire is used in the same manner to form the opposite portion of the clasps and activator. The lingual portion of the circumferential clasp is formed on the lingual surface of the anterior abutment

tooth. The wire is bent across the ridge close to the distal surface of the tooth and extended toward the buccal side of the ridge to form the buccal portion of the U-shaped activator. The wire is then extended toward the lingual, and

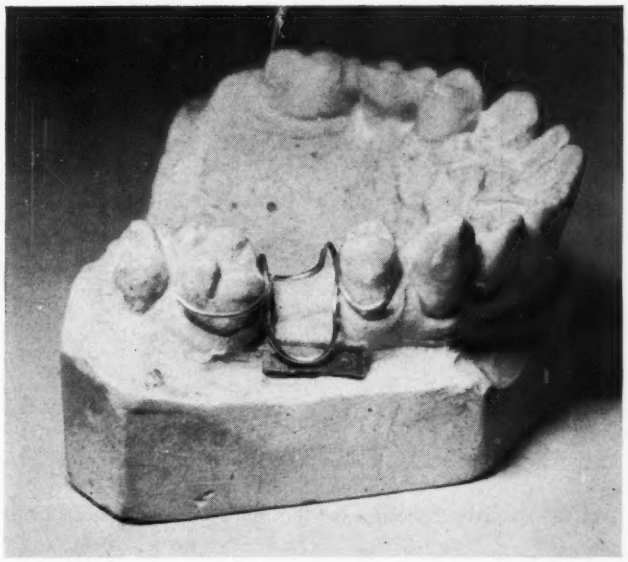

Fig. 2.—The wires are placed in position and spaced from the cast by paper matchsticks.

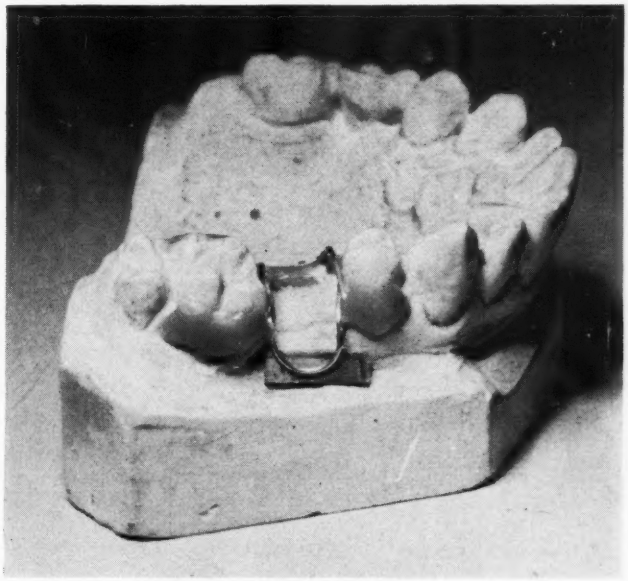

Fig. 3.—Sticky wax holds the wires in place.

the lingual portion of the circumferential clasp for the distal abutment tooth is formed. The wire is adapted into the desired undercuts on the lingual side of both teeth.

Fig. 4.—The acrylic resin is cut through from the occlusal surface.

Fig. 5.—The loops are bent to provide activation for moving the teeth.

The loose wires are removed and the edentulous area is painted with a tin-foil substitute. The wires are put back in place and held 1.5 to 2 mm. off the cast by means of sticky wax. To maintain this space, portions of a paper matchstick are placed between the U-shaped loops of the wire and the cast (Fig. 2). Wax is placed around the buccal and lingual clasp arms and at the ends of the wire loops (Fig. 3).

Enough self-polymerizing resin material is mixed to fill the edentulous area to the height of the occlusal surfaces of the teeth. This material is placed so that it engages all of the two wires except those portions covered by the sticky wax. At the end of the curing time, the sticky wax is softened and removed. At this stage, the appliance is a space maintainer. To make activation, a slice is cut entirely through the acrylic portion of the appliance from the occlusal toward the gingival side, and the U-shaped wire loop is bent with pliers at the bottom of the "U" on each side to open the loop. The amount of the bend will determine the amount of force to be applied (Figs. 4 and 5).

When conditions to as near normal as possible have been re-established and a holding time is desirable, the space that was opened up by the slice through the acrylic and by activation is filled with acrylic resin to form a space maintainer to hold the teeth in their new positions.

The establishment of proper occlusion and contact areas is often the key to the happiness, comfort, and oral and general health of patients who trust the care of their mouths to our professional ability.

747 Oakland
Iowa City, Iowa

SOME FACTORS WHICH INFLUENCE THE SURFACE OF STONE DIES POURED IN ALGINATE IMPRESSIONS

RALPH W. PHILLIPS, B.S., AND RAYMOND R. PRICE, D.D.S.*

Indiana University School of Dentistry, Indianapolis, Ind.

THE USE OF ALGINATE as an impression material in prosthetic and restorative dentistry is increasing daily.[1-4] One of the problems associated with this material, however, is the need for a hard, dense surface on the working cast, and this factor becomes especially pertinent when the alginates are used for indirect inlay techniques. Any chalkiness, irregularities, or roughness on a marginal area may necessitate a new impression.

Skinner recently conducted a series of tests to determine the hardness of stone surfaces when poured against reversible and irreversible hydrocolloid.[5] He found essentially the same Knoop hardness for the stone when either material was used, except for one brand of alginate which gave somewhat higher values. This study, however, was concerned primarily with the effect of various fixing solutions, and did not cover other factors which influence the character of the surface. There are some indications that density and surface smoothness are more critical problems with the alginates than with the reversible hydrocolloids, possibly due to the pH changes and chemical reactions taking place at the alginate-stone interface.[6]

A previous report from this laboratory covered the factors which influence the surface of stone dies poured in reversible hydrocolloid impressions, but that investigation did not include the irreversible materials.[7] Thus, the purpose of this study was to evaluate, in a similar manner, some of the manipulative variables which might alter the stone surface when the irreversible hydrocolloids are used.

PROCEDURE

The following commercial products were used in this study.

Alginate	*Stone*
Getz	Duroc
D-P	Vel-Mix
Zelex	
Coe-loid	

All of these materials were purchased on the open market. Since individual batches do vary, and since it is not the purpose of this study to evaluate the

Received for publication June 1, 1954; revised by the authors July 20, 1954.

*Department of Dental Materials.

relative merits of the different materials, the brand name of the product will not be used in this report. In all the series of tests made, dies were poured with both stones for each alginate. (Peyton has shown comparable physical properties for these two stones.[8])

The alginates were handled as nearly as possible according to the manufacturer's directions. Mixing was done in a rubber bowl and the mix was not vacuumed. The alginate was poured into a metal ring 3/8 inch high, and 5/8 inch in internal diameter. The excess unset alginate at the top of the mold was cut off flush. The outside of the mold was built up with tape in order to hold the stone which was poured onto this alginate surface.

The recommended powder-water ratio was employed, the powder being weighed on a balance and the water measured by a pipette. The stone was mixed in a rubber bowl for one minute. A mechanical vibrator, using low vibrations, was used to pour the specimen. The mechanical device used in the previous study was employed again, thus making it possible to control rate of flow into the mold.[7] With this simple apparatus it was possible to standardize the variable of vibration and rate of flow. Unless otherwise stated, the stone was allowed to harden for one hour before separation. A minimum of seven dies was made for each set of conditions, and whenever the results were erratic, additional dies were prepared. The photographs shown in this article are representative of the average.

All die surfaces were studied and photographed under X7 magnification. Uniform lighting conditions were developed, employing a grazing light to accentuate surface irregularities.

FIXING SOLUTIONS

Although manufacturers are gradually adjusting the formulas of their products to eliminate the need for any external fixing agents, some popular brands still require their use. It has been shown that, where indicated, these solutions tend to stabilize the impression if it is to be stored, and are helpful in preserving the stone surface.[3, 9] A series of dies were made to illustrate the deleterious effect on the surface of a stone die when the fixing agent is eliminated.

Fig. 1 shows the smooth surface of a stone die poured in an alginate impression which was previously treated with the fixing solution. Fig. 2 is a photograph of the surface of a stone die poured with the same stone, but poured in an impression which was not treated. A different alginate-stone combination was used, and the results are seen in Figs. 3 and 4. The extreme chalkiness is due to a surface reaction between the alginate and the stone. Since most fixing solutions are sulfates, they accelerate the set of the stone and prevent any dilution or reaction with the stone mix. Certainly, where specified, the fixer must be used according to the manufacturer's directions.

TYPE OF BOWL

Many operators prefer flexible plastic bowls and spatulas for preparing the alginate mix, and it is the feeling of some that a smoother mix can be attained. If this is true, the corresponding stone surface should reflect greater density.

Fig. 5 shows the stone surface from a die poured in an alginate impression mixed in a rubber bowl. The surface of the same stone, Fig. 6, when poured in an alginate impression which was mixed in a plastic bowl with a plastic spatula appears comparable. At least as far as smoothness of the final mix is concerned, proper use of either rubber or plastic bowls gives similar results.

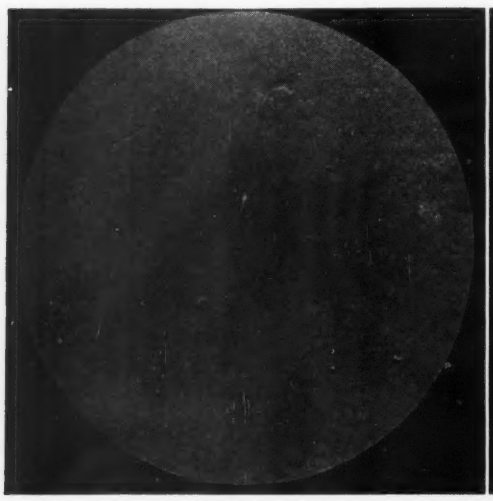

Fig. 1.

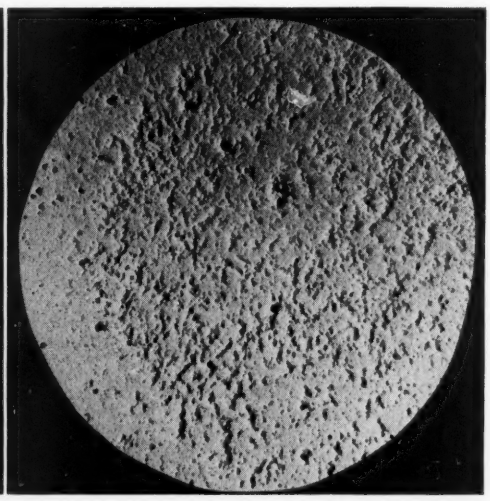

Fig. 4.

Fig. 1.—The surface of a stone die poured in an impression previously immersed in a fixing solution.

Fig. 2.—A chalky surface resulting when the fixing solution was omitted.

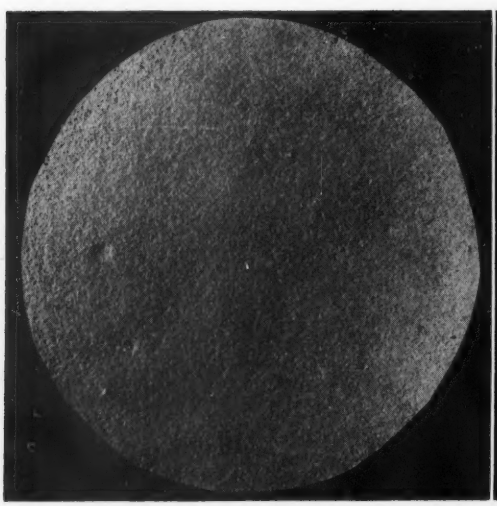

Fig. 2.

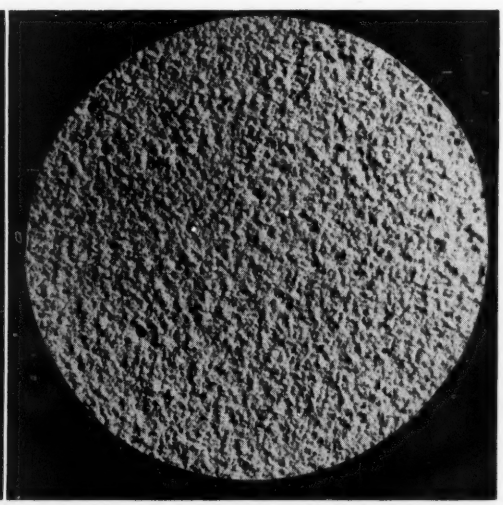

Fig. 3.

Fig. 3.—A different combination of alginate and stone. The use of a fixing solution assures a good stone surface.

Fig. 4.—A poor surface results when a fixer is not used.

LENGTH OF TIME BEFORE SEPARATION

The stone cast should not be removed prematurely from the alginate impression. The results obtained with the reversible hydrocolloids[7] were duplicated with alginate. Fig. 7 shows the rough surface of a die separated fifteen minutes after pouring. Compared to Fig. 5, where the same combination of alginate and stone was used but the stone was allowed to harden one hour before separation, the surface is rough. The difference is drastic. Maximum density is desirable and is essential on marginal areas.

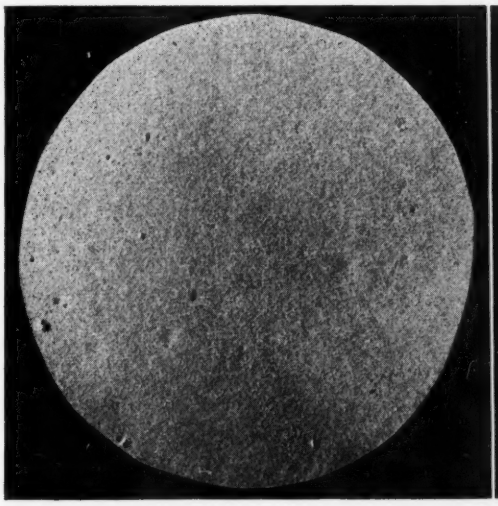

Fig. 5.

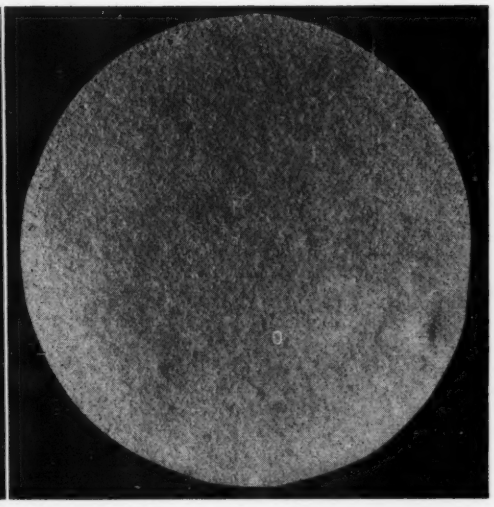

Fig. 6.

Fig. 5.—A stone surface poured against alginate mixed in a rubber bowl with a metal spatula.

Fig. 6.—The use of a plastic bowl and spatula for mixing alginate does not significantly alter the surface condition of stone die.

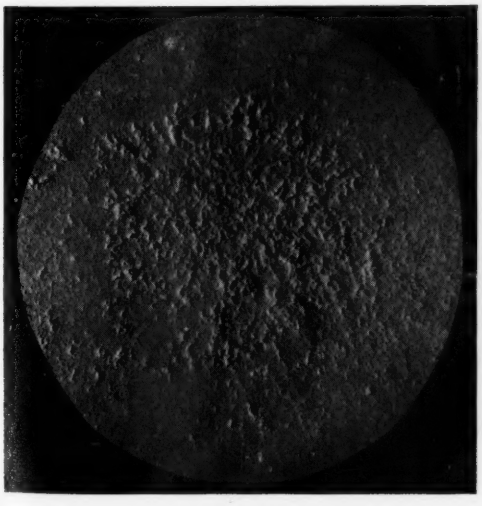

Fig. 7.

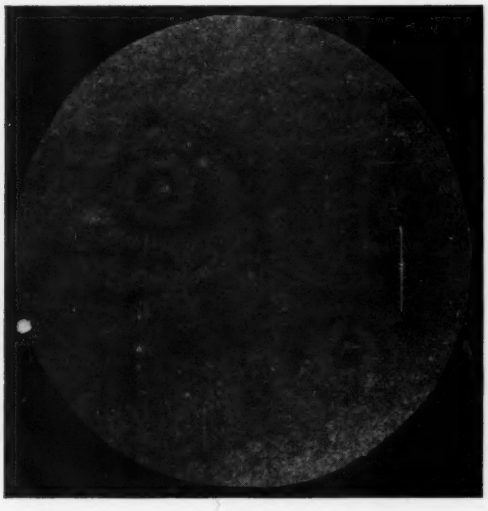

Fig. 8.

Fig. 7.—A stone surface resulting when the cast was removed prematurely. (After only fifteen minutes).

Fig. 8.—The surface resulting when the poured impression was placed back in the fixing solution during the set of the stone.

STORAGE MEDIA DURING SET OF STONE

Various techniques are advocated for storage of the poured impression while the stone hardens. Some advocate allowing the impression to remain in air, some companies suggest the fixing solution, while others recommend placing the impression in water. Specimens were prepared using these three techniques. Fig. 8 shows the surface of a die stored in the fixing agent for one hour after pouring.

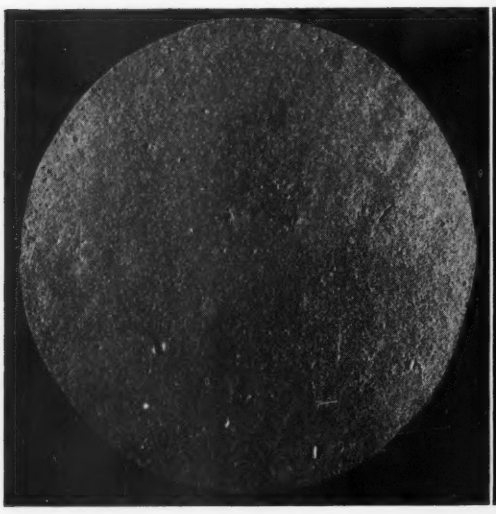

Fig. 9.

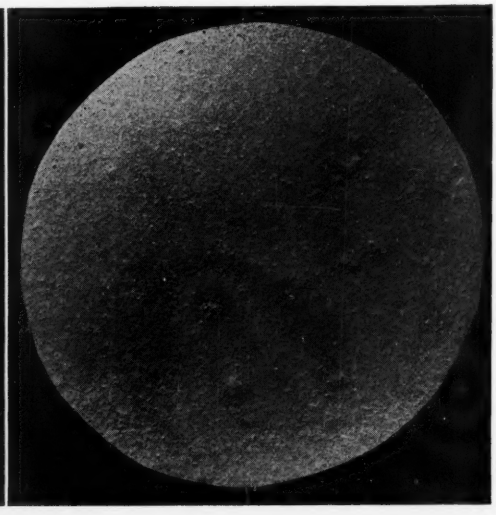

Fig. 10.

Fig. 9.—The surface resulting when the poured impression was allowed to remain in air during the set of the stone.

Fig. 10.—The surface resulting when the poured impression was placed in fixing solution during the set of the stone. The same combination of alginate and stone is used as in Fig. 9.

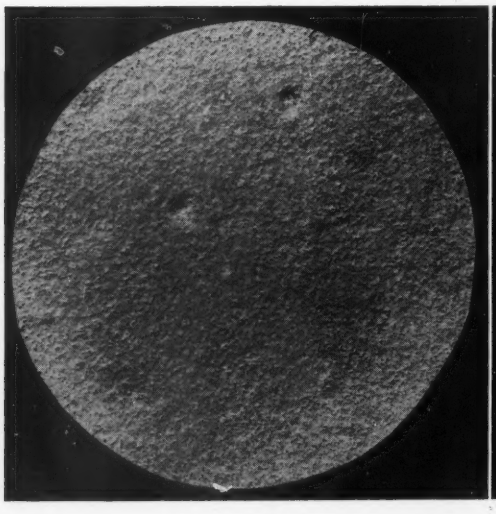

Fig. 11.

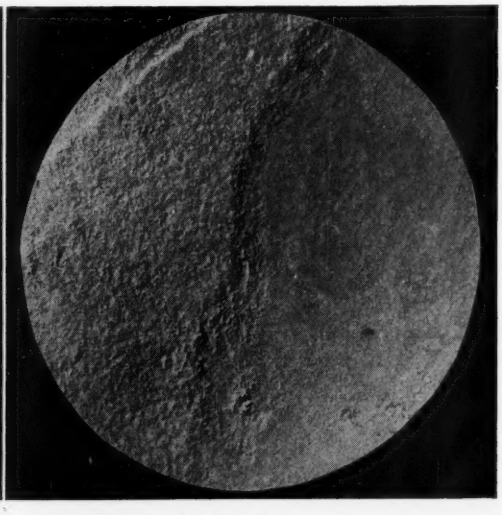

Fig. 12.

Fig. 11.—Placing the poured impression in tap water during the set of the stone produces a chalky surface.

Fig. 12.—A different combination of alginate and stone produces an inferior surface when the stone is allowed to harden under water.

Results obtained when the impression was stored in 100 per cent humidity were comparable. For comparison, in Fig. 3 can be seen the surface of the same stone poured in the same brand of alginate but stored in air for the one hour before separation. It appears that, for this particular material, the surface is somewhat better when the stone was immersed in the fixing agent. When another combination of alginate and stone was used, however, there was no difference in the stone surface (Figs. 9 and 10). Thus some materials may be benefited slightly by reimmersion in the fixer during the set of the stone while others show no difference.

Fig. 13. Fig. 14.

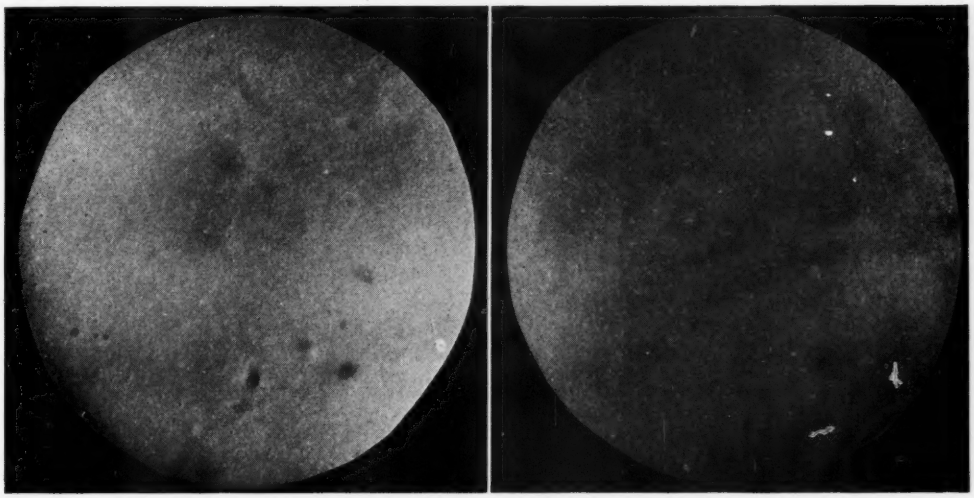

Fig. 15.

Figs. 13, 14, and 15.—Alginate surfaces after hand mixing.

Placing the poured impression back in tap water seems to be contraindicated. When two different alginate and stone combinations were used, the stone surface was very rough and chalky (Figs. 11 and 12).

TEXTURE OF ALGINATE MIX

It was apparent from a critical examination of these stone specimens and the separated alginate surfaces that a difference did exist in the smoothness of mixes attained from various brands of alginates. Some products go into solution readily, while others remain granular regardless of care or mixing procedure.

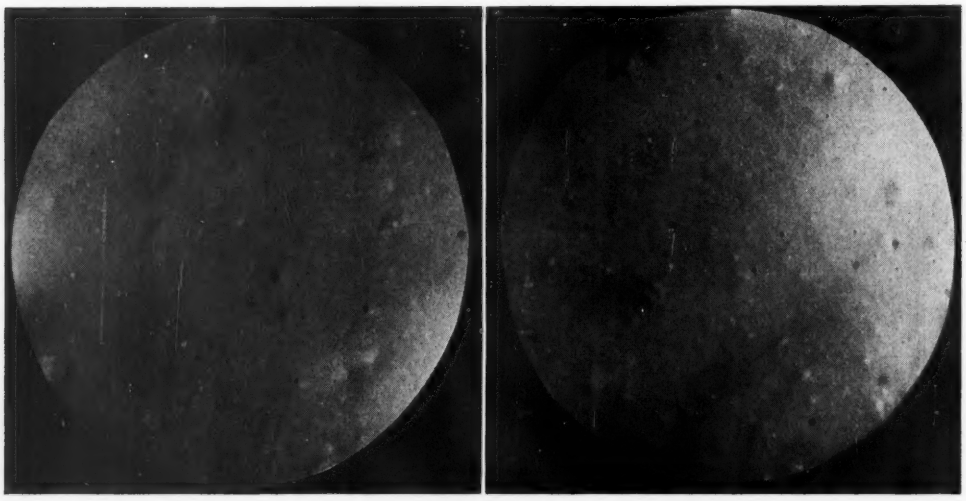

Fig. 16. Fig. 17.

Fig. 16.—The granular texture of one brand of alginate following proper mixing.
Fig. 17.—The granular surface of another properly mixed alginate.

This fact was substantiated when alginate surfaces were photographed. One additional popular brand of alginate was included with the four employed previously in this study, and the five surfaces are compared in Figs. 13 to 17. It is obvious that two products (shown in Figs. 16 and 17) contained granules which did not go into solution, even under very careful and adequate spatulation, and would be more likely to produce granular or porous areas on the stone cast. The remaining three products were comparable.

Specimens were also prepared making the mix with vacuum equipment. Although there was a reduction in air voids, the granular texture of these two brands remained.

SUMMARY

Critical examination of stone surfaces which have been poured into alginate impressions reveals:

1. Fixing solutions must be used where they are specified by the manufacturer.
2. Plastic bowls and spatulas for mixing alginate do not produce superior stone surfaces on casts.
3. With the particular alginates tested, placing the poured cast in tap water during the set of the stone produced an inferior surface.

4. The stone cast must not be separated before one hour.
5. There is a difference in the texture of the mix attained from various commercial brands of alginate.

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1121 W. Michigan St.
Indianapolis 2, Ind.

THE EXTERNAL PTERYGOID MECHANISM

HOMER CREE VAUGHAN, D.D.S.

New York, N. Y.

THE purpose of this article is to present a case of dysfunction of the right external pterygoid muscle in order to further describe the physiology of the temporomandibular joint, the function of this muscle, and its relation to the stomatognathic system.[1]

This accidental nerve injury presents a most important case of dental interest. Except for the comments on the Bennett movement, the observations contained herein have been observed and can be demonstrated in many other patients.

This article is correlated with 500 feet of Kodachrome motion pictures[2]; is also correlated with "A Study of the Temporomandibular Articulation,"[3] and "Temporomandibular Joint Pain—A New Diagnostic Approach."[4]

This patient affords an unusual opportunity to study, in vivo, the function of the external pterygoid muscle; especially so because all of the anatomic parts are present and not surgically traumatized, and the other muscles are intact and uninjured, and because it is a painless defect, eliminating to a great extent the guidance of the proprioceptive and epicritic reflexes.

This was a case of tic douloureux affecting the right side of the face. It was operated twelve years ago. In doing the nerve notch (dorsal section of the fifth nerve entry through the squamous bone), two things occurred. First, the tic was completely relieved; second, the motor nerve fibers supplying the right external pterygoid muscle were destroyed, leaving the patient with apparently all masticatory and facial muscles normal except the right external pterygoid.

Further, this patient offers an opportunity to examine and to determine what muscle groups, or what muscles, control mandibular movements, and what, if any, substitution takes place, and to determine what effect this loss has on the temporomandibular joint.

In the years 1935, 1936, and 1937, a quantitative study was done on cadavers as the first necessary step in attempting to formulate sound oral rehabilitation methods.[3] The conclusions arrived at through this study were (in part) as follows:

1. That forces influencing the temporomandibular joint must be viewed primarily through the concept of a voluntary neuromuscular skeletal mechanism. This is a fluid concept.

2. That the temporomandibular joint is subject to continuous anterior pull throughout life. This is an observation which I have considered a basic law, an understanding of which is necessary before clinical therapy can be advanced for the management and treatment of this joint.

3. That the temporomandibular joint is subjected to wear and change.

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 15, 1954.
Received for publication April 30, 1954.

4. That the opening act is a tilting act performed by the external pterygoid and the suprahyoid muscles.

5. That the anterior and anterior lateral edge of the meniscus can be traumatized.

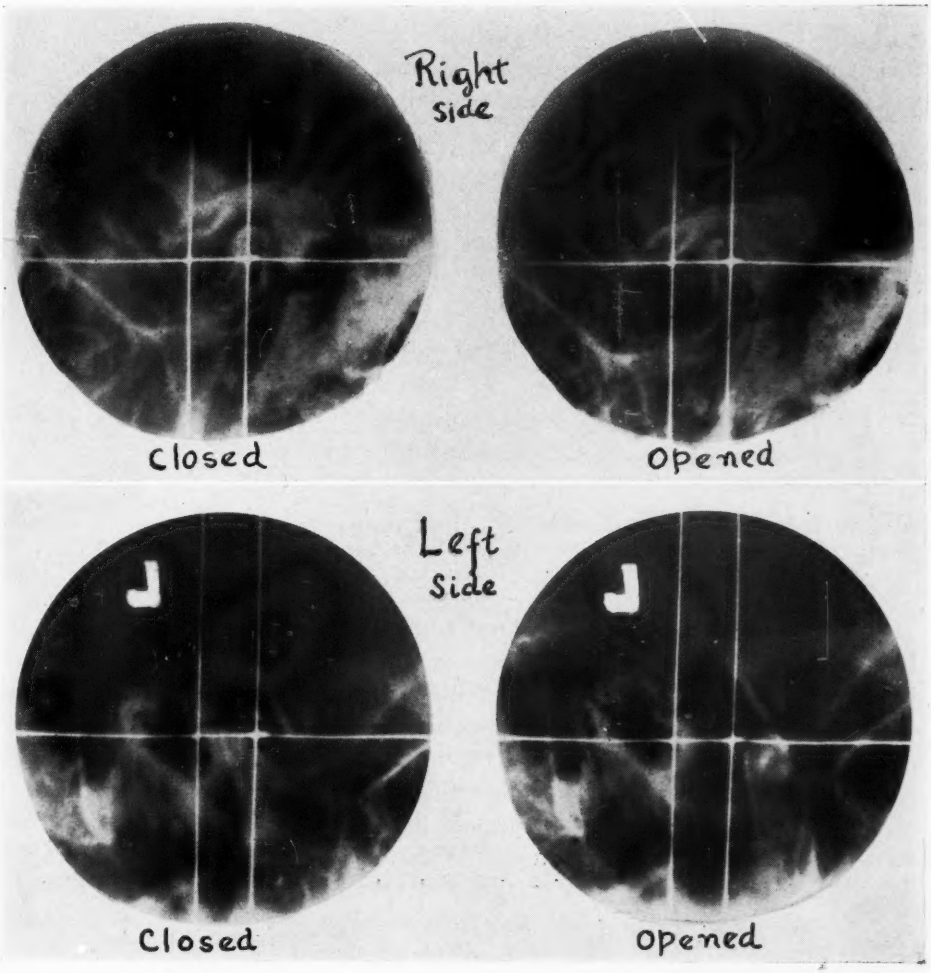


Fig. 1.—The right side is the affected side. Absence of external pterygoid muscle function permits the condyle to be displaced distally as far as the bony parts will permit. There is no protraction of the condyle on opening; there is a superior thrust or rising toward the eminentia. The left side shows a wide range of movement. (Updegrave technique.)

This rare case offers an opportunity to check these conclusions which were made from studies of cadavers, and to increase our knowledge of mandibular behavior. The patient, aged 70 years, has been most cooperative, and is as free from anxiety and other emotional factors as is humanly possible. She has been observed for many years.

OBSERVATIONS

1. With a nonfunctioning external pterygoid muscle, the condyle is displaced as far posteriorly as the bony parts will permit (Fig. 1). This completely corroborates the observations made on cadavers, and confirms what I feel is a basic law, that the condyle is subjected to a continuous anterior pull throughout life.[3] Stated otherwise, the position of the condyle is maintained in relation to the eminentia articularis and meniscus through the action of the external pterygoid muscle. When this muscle no longer functions, the condyle moves distally as far as the bony parts will permit. This muscle action is of real importance to all specialties of dentistry.

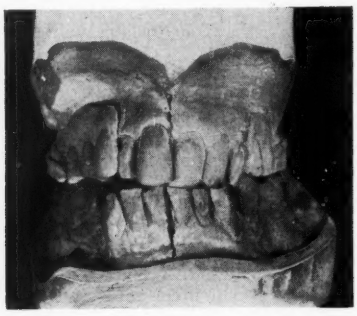


Fig. 2.—The articulated study casts. There is molar contact through the first molar teeth. Note the midline for reference. There is a slight rotation of the mandible to the right—the affected side. Originally, it presented an ideal jaw relationship.

2. Tooth support is present through the first molars on both sides (Fig. 2). Roentgenograms demonstrate that there is no initial superior thrust of the condyle in the opening tilt; this thrust started at 0.6 cm. of opening. This partially confirms the conclusions of Wilson[5] and Robinson.[6] In this case, the superior thrust developed in the last two-thirds of the opening tilt, even in this most retruded position. Roentgenograms show that this upward movement is related to the speed of opening; the faster the opening, the sooner it develops. Fig. 3 shows a series taken with wax incisal props. With this slowly graduated opening (with light incisal support), a superior thrust developed in the last two-thirds of the opening tilt. It is well to point out, however, that this movement of the condyle will vary in many patients as the mandible performs the anterior glide, and will be influenced by a deep or shallow eminentia. From rest position to occlusion and any point posteriorly, the interarticular elements are not pressed together, even in abnormal behavior originating from indirect trauma.

3. During the opening act (Fig. 4), it is easy to observe the bizarre movement of the mandible to the right (toward the affected side). This could only occur if the left external pterygoid muscle functioned with every movement.

4. The opening movement is extreme and done with reckless abandon, clearly emphasizing two points: (a) The power is supplied by the suprahyoid musculature during the opening act, and (b) the external pterygoids are not necessary for the performance of the opening tilt. The amount of restriction brought into

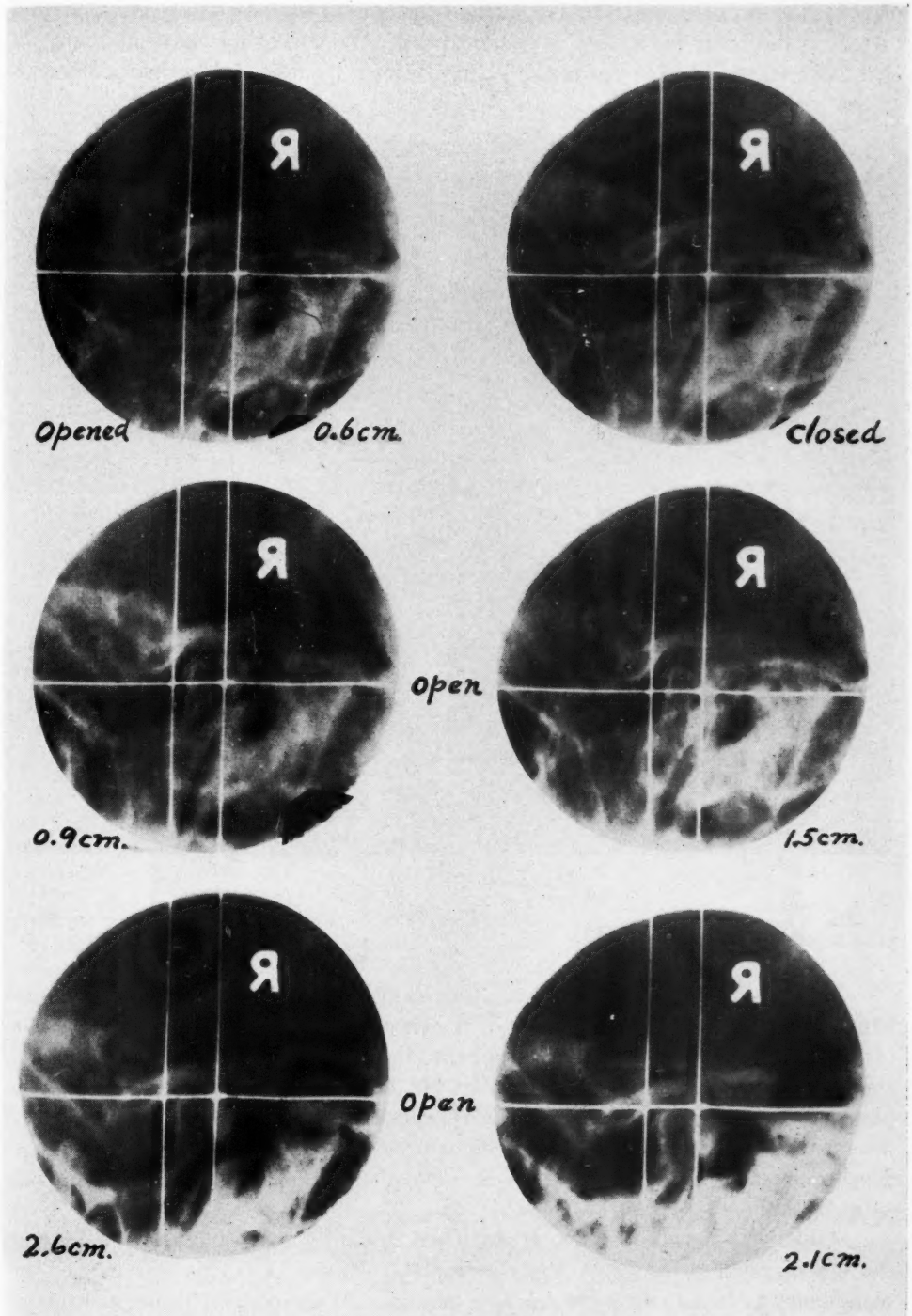


Fig. 3.—Roentgenographic series with wax incisal props. With this slow, slightly supported opening, the superior thrust began to develop at approximately 0.6 cm. opening for this patient.

play by the proprioceptive and epicritic sensibilities in controlling muscles, and thereby mandibular movement is demonstrated here, for in this patient, the right side has been rendered insensible and painless from the joint to the inferior border of the mandible.

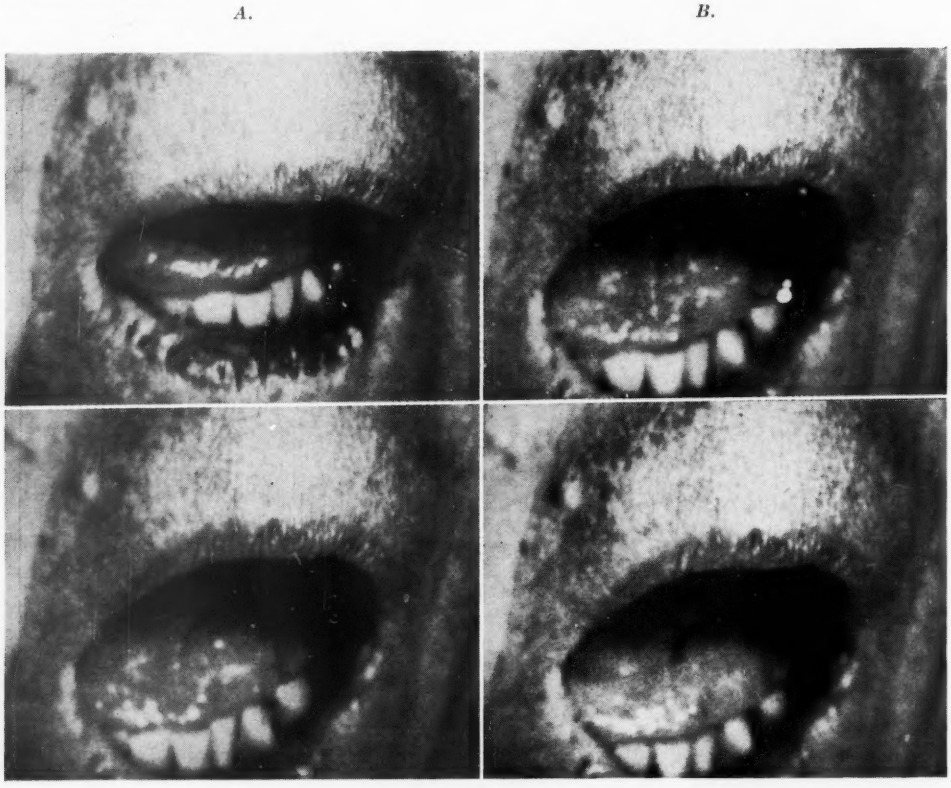


Fig. 4.—Four frames from the motion picture showing the opening tilt. Notice the movement to the right toward the affected side.

5. In examining the horizontal and vertical overlaps, and even the midline which is deflected to the right, little is evidenced as to the degree of posterior displacement of the right condyle. Originally, the patient had an ideal jaw relationship. This condition is now twelve years old, and many compensations have taken place. These compensations occurred between the ages of 58 and 70 years, and demonstrate the adaptability of the stomatognathic system by adjusting so as to synchronize the defect until now it is impossible to detect it in the resting face (Fig. 5).

Although the right mandibular condyle is displaced distally to a marked degree, the incisal midlines are only slightly displaced (Fig. 2). This has carried the mandibular molars on the right side to a more distal relationship. One might, however, expect a wider deflection of the midlines. The mandibular molar is in firm contact as checked by an effort to pass dental floss between the contacting teeth (Fig. 6). There is a slight change in the anteroposterior relationship of the teeth on the left side.

Three possible changes have occurred: (a) The left condyle was reduced in size due to its excessive anterior movement. (b) The joint ligaments have relaxed. (c) The mandible has been recontoured in response to a change in muscle action.

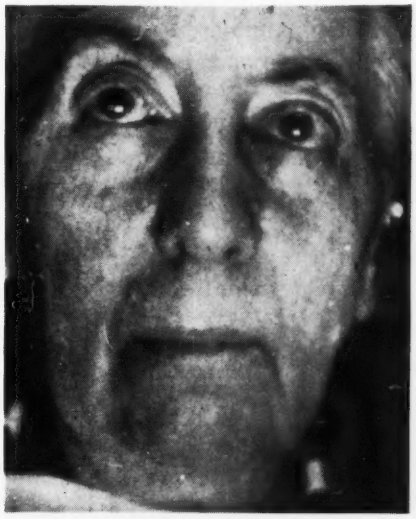
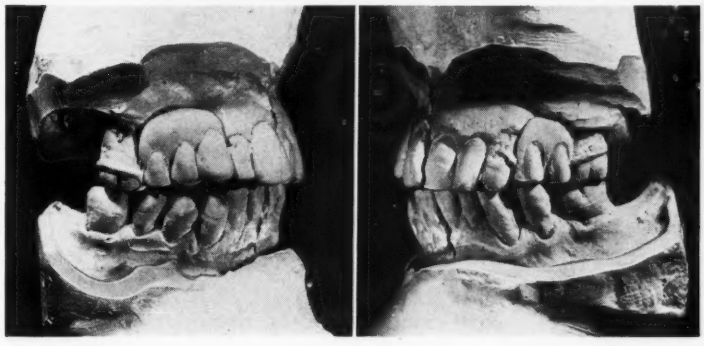


Fig. 5.—The resting face. It is impossible to detect any defect.



A. *B.*

Fig. 6.—*A,* The teeth on the right (affected) side have been carried distally with a slight medial shift of the molar. *B,* The teeth on the left (unaffected) side show little antero-posterior change and no medial shift of the molar.

I believe the medial displacement of the right mandibular molar is due primarily to the stabilizing action of the internal pterygoid muscle during the constant rotation of this mandible to the right. The mandible is a flexible bony mass. This can be observed by pressing the index fingers against both angles of the mandible toward each other, and simultaneously tapping the teeth together slowly. The lower buccal cusps can be made to occlude quite easily with the upper lingual cusps.

I believe that unilateral internal pterygoid muscle action during rotation can affect the angle of the jaw permanently by pulling it inward, and that this accounts for some facial irregularities.

As this case developed, the midline shift seemed to be caused more by the healthy left external pterygoid muscle than the distally displaced right condyle. This will appear more evident in the observation on the Bennett movement. It emphasizes again the paramount importance of muscles and the ability of the skeletal body to adjust.

6. While these jaws were well related before this operation, and the teeth could be occluded, the casts cannot now be occluded in any set position off the articulator.

7. There is no interocclusal rest space between these teeth. The teeth are occluded at all times, probably a response to the proprioceptive sensations emanating from the left side and stimulated by the discomfort or the effort to correct an irregular mandibular position.

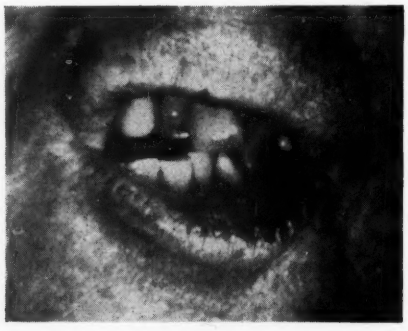


Fig. 7.—Rotation to the right is so extreme when it is unopposed by an external pterygoid muscle that it cannot be accommodated on an articulator. (From the motion picture[2]).

8. The tongue mass cannot move this mandible to the left.

9. The restraining influence of the opposing external pterygoid muscle is clearly demonstrated (Fig. 7).

10. There is no protrusive excursion of the mandible with one external pterygoid muscle not functioning. There is no lateral anterior glide with one external pterygoid muscle not functioning. The antagonistic action of two of these muscles is needed to perform an anterior glide or an anterior lateral glide.

11. No other muscle or muscle group can replace the function of the external pterygoid muscle.

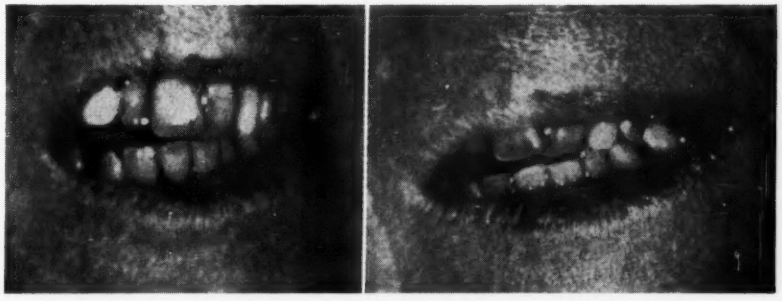
12. It is quite apparent that the opening movement or tilt would be the only movement the mandible could perform without the external pterygoid muscles. There would be no masticatory cycle as it is commonly described.

13. It is equally evident that the external pterygoid muscles are the only muscles which can perform the glide, or rotate the mandible.

14. With these thoughts in mind, one would expect the left joint to respond to a great degree according to the general behavior of the muscle, and limited by

pain or other discomfort, the bony parts involved, and the behavior pattern which had already been developed. For example, I would expect the left external pterygoid muscle to be overdeveloped—to be a little more contracted than it might otherwise be.

After a considerable retraining effort, being careful not to injure the left condyle by overexercise, further information was obtained. First, an effort was made to relax the left external pterygoid muscle by guiding the mandible firmly to try to develop the "feel" of a left movement. Then the patient was directed to thrust the tongue mass hard to the left. The midline was not altered in the slightest degree. The patient was asked to keep trying, and as the efforts continued (through several visits), the thought and the sensations of left movement (the idea) began to develop. After a time, it was possible to get the mandibular incisal midline to pass slightly (about one-half the width of a lower central incisor) to the left (Fig. 8). These were transient movements since the patient was unable



A. *B.*

Fig. 8.—The midline of the lower arch is moved from the right to the left without protraction. The movement is caused by further extension of the left external pterygoid muscle (primarily). It offers a possible explanation of the Bennett movement.

to hold them for more than a few seconds. At first, this seemed to be due to the action of the left buccinator muscle, for the patient used this muscle with great effort. As time and more effort were used, I discovered that this slight shift could be performed with cheek retractors in place. This seemed to demonstrate that the left external pterygoid muscle could be made to relax further. It offers a possible explanation of the Bennett movement, according to the established laws of extensibility and elasticity of muscle tissue.[7] The extension was due to further relaxation or a stretching of the external pterygoid muscle. When the Bennett movement is present, the lateral shift occurs because of the normal tonus, or even a slightly greater contraction of the opposite external pterygoid muscle, along with some relaxation of the internal pterygoid muscle on the rotating side. It suggests that the Bennett movement could be an attempt to relieve a unilateral strained rotation and the uncomfortable feeling it could produce.

15. After a two- or three-hour session for the motion picture work associated with this patient, a sound was audible during the excursions of the left condyle. This sound would disappear after a day of rest and would not be noticed particularly by the patient. It was muffled, but audible at chair-operating distance. As soon as it appeared, work was stopped to avoid painfully traumatizing the joint.

SOUNDS IN THE TEMPOROMANDIBULAR JOINT

There have been many efforts to explain the various sounds produced by temporomandibular joint movement. Most of these are inadequate and not supported by real evidence. More recently, Sicher and Thompson have explained the "click" as the result of a posterior superior displacement of the condyle which causes it to pass over the posterior border of the meniscus.[8] I believe this to be in error for the following reasons:

1. In my dissections of 68 cadavers and observations on more than 120 cadavers, I did not record a single meniscus showing evidence of abraison on the distal or medial margins.

2. I did find that the anterior border and the lateral edge of the meniscus showed definite signs of abrasion and contusion in 17 per cent of the cadavers.

3. I find condyles displaced distally but not superiorly in roentgenograms. The possibility of the stretching of the posterior capsular fibers was called to my attention in a personal communique with Schuyler in 1940.

4. This patient demonstrates definitely that a superior thrust, even with a posterior displacement, develops only in the last two-thirds of the *opening tilt*, and the degree of superior thrust is related to the speed of opening.

I offer a different explanation, which is indicated by my anatomic observation, clinical evidence, and the patient being discussed. When you listen to other joints in the body, either by placing an ear over the joint or through a stethoscope, you will find that most joints have an operating sound which does not invade the conscious perception of the patient.

Observations on cadavers definitely establish the fact that the condyle can be protracted over and beyond the anterior border of the meniscus, and that the lateral anterior edge of the meniscus can be contused. I believe this protraction accounts for the bumping one feels during the mandibular glide in these patients. The bumping could easily be a double bounce, one as the condyle passes over the meniscus, and again as it passes forward over the crest of the eminentia. The eminentia is not the anterior limit of movement in all patients, especially those with shallow fossae. This is easily demonstrated in the cadaver. An example of extreme condyle movement is shown in Fig. 9.

I believe the loud clicking sound is caused by fluid which has collected as a result of an injury. The play of fluid between the tendons, the adjacent bony parts, and the fascial sheaths produces this click. I parallel this to the fluid which can collect at the lower anterior tibial portion of the leg (pretibial swellings) due to an unusual strain (Fig. 10). At stage 2 in recovery, movement produces a click which can be heard at distances of 10 to 15 feet. In pretibial swellings, the sound appears when considerable fluid has been absorbed, i.e., when recovery is well advanced.

Fig. 11 shows the possible areas for fluid collection. In this patient, time was allowed for the fluid which I felt would collect from the trauma of excessive exercise to be absorbed to a more normal physiologic balance.

DISCUSSION

It becomes increasingly clear that we are dealing with a mechanism consisting of the external pterygoid muscle, the meniscus, and the condyle. This I have termed the external pterygoid mechanism (Fig. 11). Harmony of these three moving parts is essential for joint health.

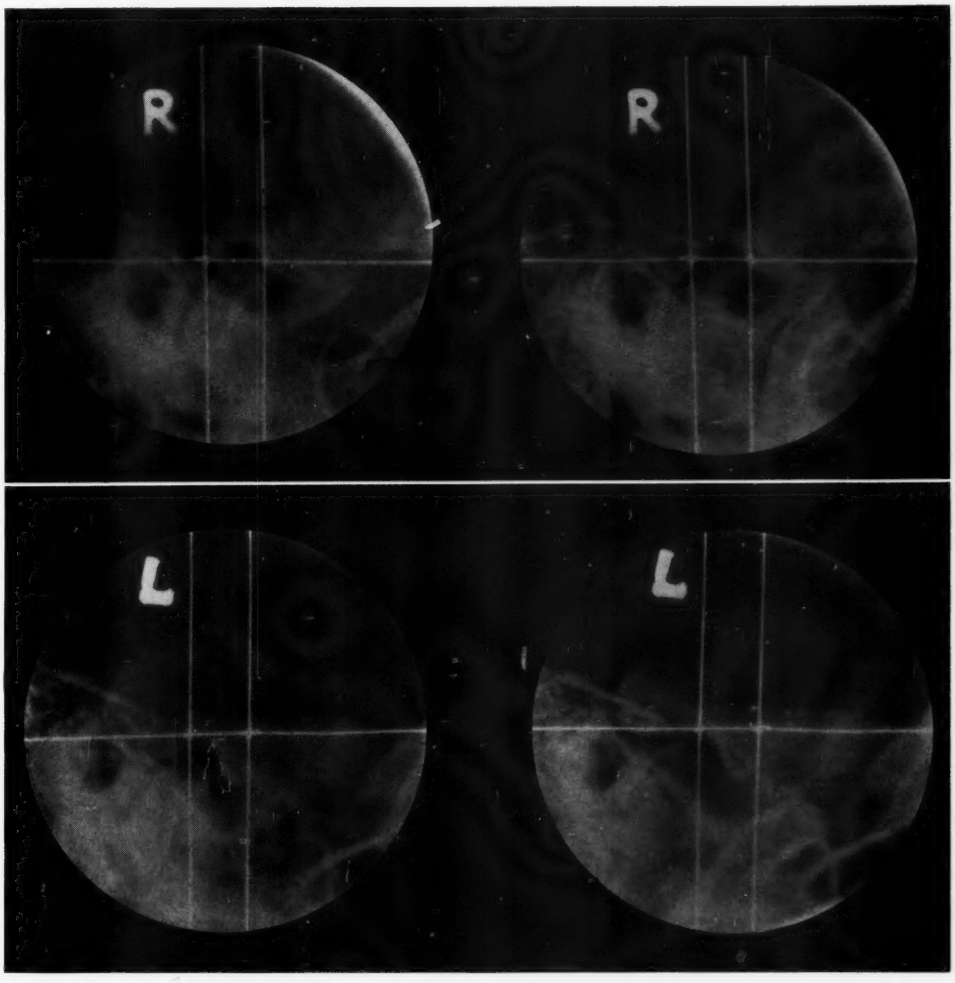


Fig. 9.—Two symptom-free joints. Note the crest of the eminentia is not necessarily the anterior limiting border.

Traumatic involvement of the external pterygoid mechanism is the primary anatomic part which we treat. When it is involved, it accounts for one variety of cephalalgia which is often confused with the menopausal headache, cervical arthritis, facial neuritis[4] and may exhibit a concomitant syndrome which I have termed an indirect traumatic syndrome (Fig. 12).

This case confirms what I feel is a basic law—i.e., the condyle is subjected to a continuous anterior pull throughout life.[3] Stated otherwise, the normal position of the condyle is maintained in relation to the eminentia articularis through the action of the external pterygoid muscle. When this muscle no longer functions, the condyle moves distally as far as the bony parts will permit. This is of real importance to all specialties of dentistry.

With bilateral molar support present, the direction of condyle movement with external pterygoid dysfunction is distally but not superiorly. There is evidence that a superior thrust does develop during the last two-thirds of the opening tilt, and that it will start sooner with a fast opening.

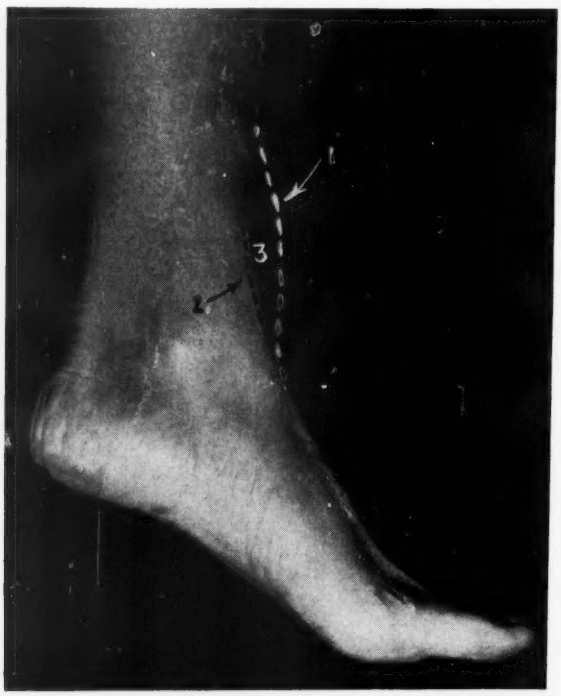


Fig. 10.—Pretibial swelling. *1*, No sound is produced at the maximum contour because of loss of motion. *2*, No sound is produced on motion of the normal joint after healing. *3*, A loud "click" was audible at ten to fifteen feet at this stage of recovery upon motion.

This case clearly demonstrates that the voluntary neuromuscular skeletal action of mandibular movement can be divided into two essential phases which are capable of independent movement: first, an opening and a closing tilt, accomplished principally by the suprahyoid musculature and the external pterygoid muscles when they are healthy; second, the action of the external pterygoid muscles which gives to the mandible the glide or its movement in the third dimension.

It is demonstrated that the external pterygoid muscles are solely responsible for the glide. It is during the performance of the glide that the temporomandibular

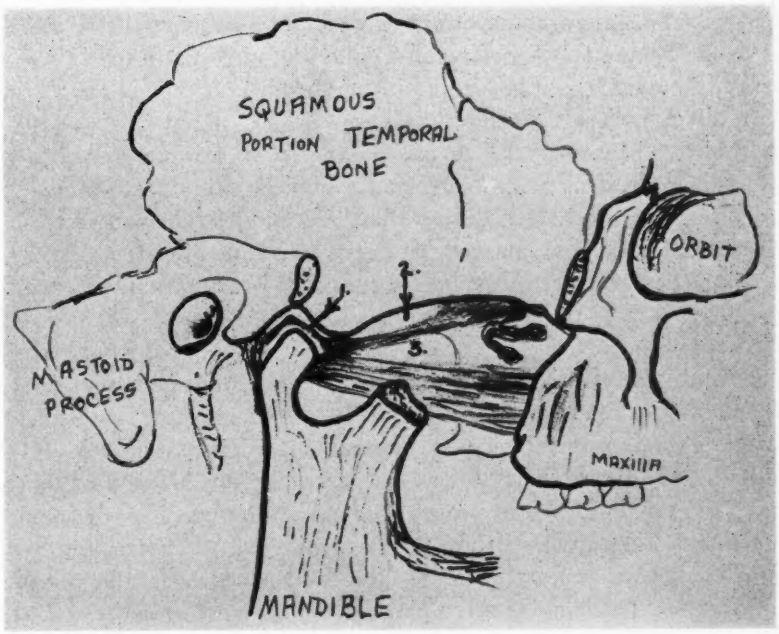


Fig. 11.—Schematic drawing. Regions *1*, *2*, and *3* can collect fluid. Evidence obtained from palpating and treatment with hyaluronidase indicates that regions *2* and *3* are the primary regions in which fluid collects. This drawing outlines the external pterygoid mechanism: the muscle, the disc, and the condyle.

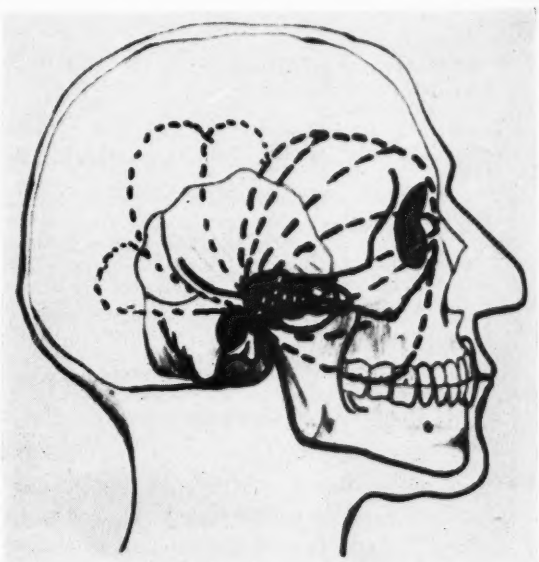


Fig. 12.—The relative position of the "trigger area," the heavy disc over the infratemporal fossa and joint. The referred area is indicated by dotted lines. (Redrawn from Vaughan, Traumatic Temporomandibular Syndrome, U. S. Nav. M. Bull., April, 1954.)

joint exerts its greatest guiding influence in mandibular movement. The mandibular glide is a very sensitive movement. The size and relation of the coronoid processes to the infratemporal fossae also guide the glide pattern.[4] I feel that the joint offers little guidance or influence on the opening tilt, but is the victim of the muscle curtain in which it is embedded.

It is this two-phased act, each phase capable of working together or independently, which explains why Kurth[9] and Jankelson and associates[1] found no resemblance in muscle behavior during the glide and the chewing act.

The external pterygoid muscles have no substitute muscles. They are not necessary to the performance of the opening tilt, but when present and healthy, they perform with each act.

Translated into one facet of prosthetic practice: our efforts to register the mandibular glide are related entirely to the manner of function of the external pterygoid muscles. These muscles permit an anteroposterior adjustment of the interarticular elements, which, in my opinion, makes it physiologically incorrect to continue the use of the word "hinge" in describing any portion of the action of this joint. It is possible, in many cases, to stabilize the opening tilt about an axis. It is the action of the muscle curtain that is registered. If the points of this axis happen to coincide with the articulating facets of the condyles, then we might say we have theoretical harmony of these parts. At all times, however, a fast opening could also alter this registration.

The temporomandibular joint is a flexible joint, consisting of compressible and displaceable tissues. When left to its own voluntary neuromuscular impulses, it is capable of three-dimensional movement at any time.

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608 Fifth Ave.
New York 20, N. Y.

A METHOD OF PRODUCING ROENTGENOGRAMS OF THE TEMPOROMANDIBULAR JOINT

THURE BRANDRUP-WOGNSEN, L.D.S.

Stockholm, Sweden

BY STUDYING THE literature on roentgenography of the temporomandibular joint, we find many methods of producing such roentgenograms described during the last twenty years.

In the beginning of the thirties, Parma[1] (Czechoslovakia) described the following method. The patient is placed with the median sagittal plane of the head in a vertical position. The cassette is also placed in a vertical plane as close as possible to the condyle area. The tube of the x-ray machine is directed in such a way that the central beam enters the head immediately in front of the external auditory meatus. Then the beam passes in a horizontal direction to the opposite glenoid fossa. The mouth is kept wide-open during the exposure.

Steinhardt[2] (Germany) proceeded in a similar manner, with the exception that the central beam entered the head at a point situated 5 cm. in front of the auditory meatus and the same distance below a horizontal plane through the meatus. Steinhardt also had the patient's mouth wide-open during the exposure.

It is evident that, when employing one of the previously mentioned methods, we do not get such pictures of the joints as we require from the odontologic point of view. We need pictures in quite another plane. In order to study the various positions of the condyle in relation to the fossa and the eminentia, the central x-ray beam must coincide with the longitudinal axis of one of these parts.

Higley[3] set about from this principle when elaborating his method. As a center of the area to be roentgenographed, he chose the crest of the eminentia. He examined a large number of skulls and cadavers in order to find out in which direction this crest runs in relation to a vertical plane through the external auditory meatus at a right angle with the Frankfort plane. He found the crest to have a backward inward angulation of 20 degrees to this plane. In relation to the horizontally situated Frankfort plane, the angulation was 6 to 8 degrees inward downward. Furthermore, Higley stated that the longitudinal axis of the fossa as well as that of the condyle were similarly directed in the majority of cases. Only certain variations of the latter could be observed. With these investigations as a basis, Higley built a contrivance for making roentgenograms with the central beam coinciding with the longitudinal axis of the crest of the eminentia. From the scientific point of view, no objections to this method can be raised, and good pictures of the joint are obtained in most cases. Sometimes, however, bony processes of the base of the cranium overshadow the pictures, and, in these cases,

Received for publication April 2, 1954.

Higley's method may not give good results. In my opinion, his apparatus is too expensive and too complicated to be used in private practice. It is more suited for use in the x-ray departments of hospitals (Fig. 1).

These superimposing bony parts have also been the problem of other investigators, and efforts have been made to find another direction for the central beam. Empirically, it has been found that if we make a roentgenogram with the central beam passing through the center of the condyle, and directed in an angulation of 15 degrees to the Frankfort plane from above and from the opposite

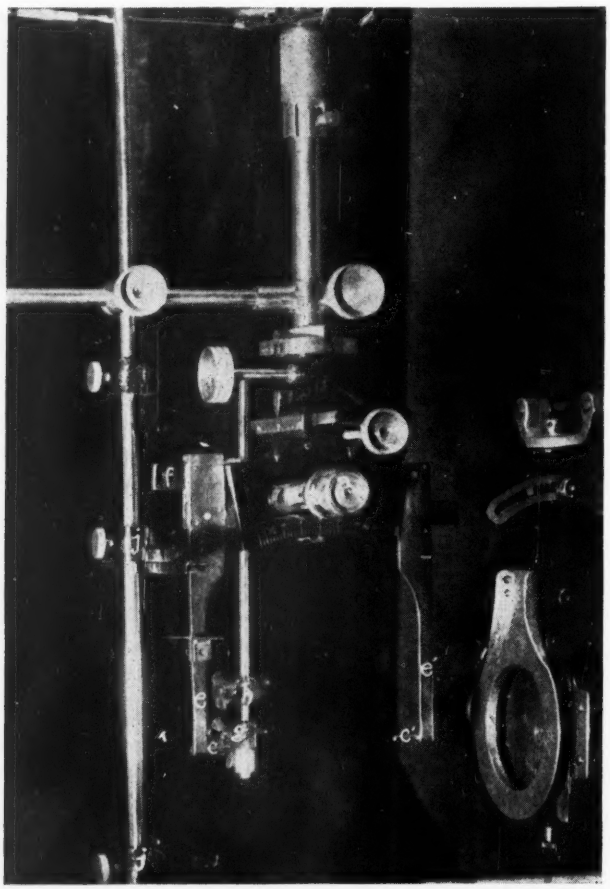


Fig. 1.—Higley's apparatus. (From Higley.[3])

side of the head, and from behind in the same angulation to a vertical plane (which is situated at right angles to the Frankfort plane), the roentgenogram will be almost identical to the one produced in accordance with Higley's method. If, as sometimes happens, the petrous part of the temporal bone interferes with the central beam, the direction from above must be altered to about 20 degrees or more. It has not been explained, as far as I know, why we get satisfactory

roentgenograms when this direction of the central beam is used. When studying an ordinary condyle from its frontal face, we find that it can be divided into a medial and a lateral part (Fig. 2). When we make roentgenograms by the technique described above, the central beam will coincide with the axis of the lateral part of the condyle, and, the fossa being shaped in a similar way, the roentgenogram will be almost the same as that produced with the central beam coinciding with the longitudinal axis of the condyle.

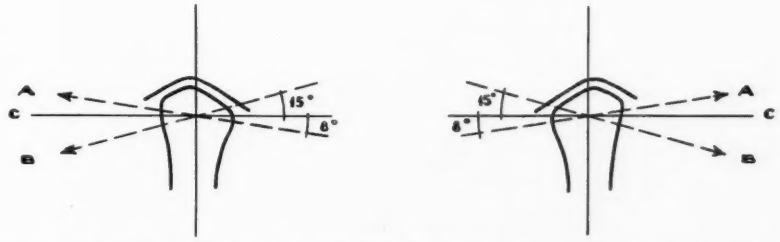


Fig. 2.—Sections of the right and left condyles. The sections are passing through the longitudinal axes of the condyles in planes at an angle of 15 degrees from behind laterally to the frontal plane. The lines (*A*) indicate the directions of the x-ray beams according to Higley's method, i.e. they are coinciding with the longitudinal axes of the condyles. The lines (*B*) indicate the directions of the beams according to the author's method. This beam direction is parallel to the lateral part of the upper margin of the condyle as well as to the lateral part of the surface of the fossa.

Lindblom[4] (Sweden) and others make roentgenograms in this empirically established direction (15 degrees from behind and above).

My own method is also based upon these presumptions. My apparatus is much easier to manipulate than all former contrivances, and, what is particularly important, *the head of the patient can be placed in any position.* As a rule, the head must be held in a certain position, with the median plane held vertically or lying on a desk or other device.

THE APPARATUS

The apparatus consists of two parts.

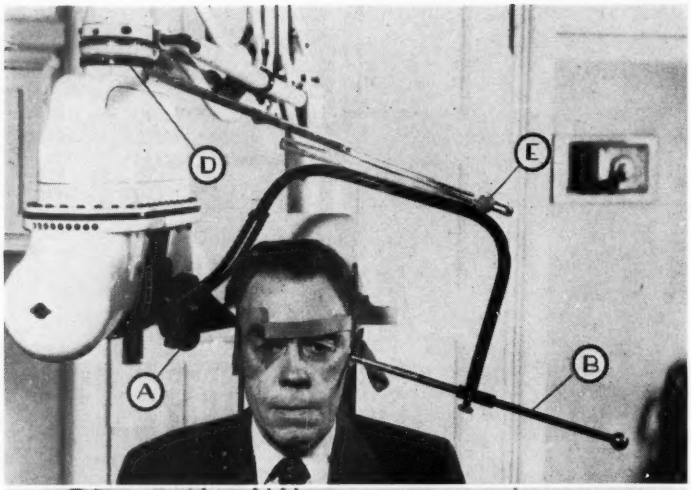
Part I.—At one end of a metal arch, there is a ring with a locknut (*A*) (Fig. 3), and at the other end a rod (*B*). The rod can be moved forward and backward through a small tube at the end of the arch. The arch is attached to the x-ray machine in a simple manner. The ring with the locknut (*A*) fits to the tube of the x-ray machine. Another device which is locked with a ring (*D*) to the upper part of the machine supports the arch, which can be fixed in various positions by the locknut (*E*). The rod (*B*) coincides with the central x-ray beam, and at the same time, it supports the cassette holder at *C* (Fig. 4).

A description of such an apparatus was published first by Professor Gustav Herulf[5] at the Royal School of Dentistry at Stockholm. It was constructed by him for making periodical extraoral roentgenograms with identical positions of the patient.

Originally, I had constructed a similar arch, but I now use Professor Herulf's apparatus because it is better constructed from the technical point of view.

Part II.—The second part of the apparatus is my own invention. To a transparent celluloid plate of the dimensions shown in millimeters in Fig. 5, a rubber

Fig. 3.



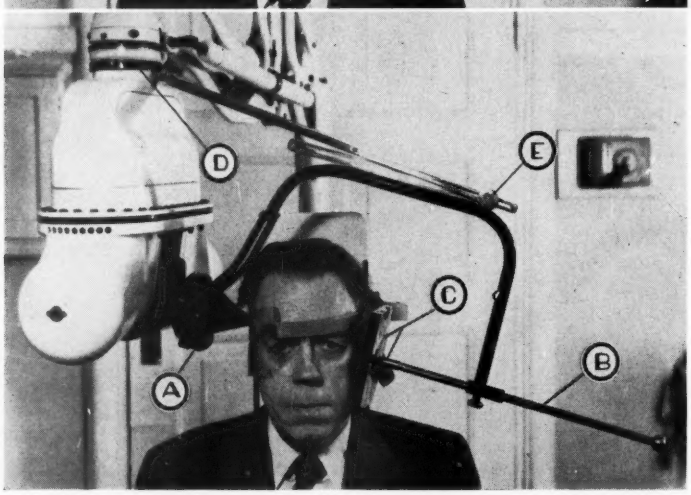


Fig. 4.

Fig. 3.—A patient with the author's apparatus in position (without the cassette holder).
Fig. 4.—The apparatus with the cassette holder in position.

band (*D*) is attached, with which the plate can be fixed to the patient's head (Figs. 3 and 4). There are two holes in the plate (*A* and *B*). Hole *A* is placed at the condyle point of the side opposite to the joint to be photographed, and the line *C* of the plate has to be placed in such a manner that it touches the lower border of the bony orbit, thus coinciding with the Frankfort plane. Hole *B* is the point where the cone of the x-ray machine is to touch the transparent celluloid plate.

The arch is placed in such a position that the central beam indicator touches the condyle point of the opposite side of the head (Fig. 3). The apparatus is then in its correct position. The central beam indicator is removed from the condyle point, and the cassette holder with the cassette is placed in position. The

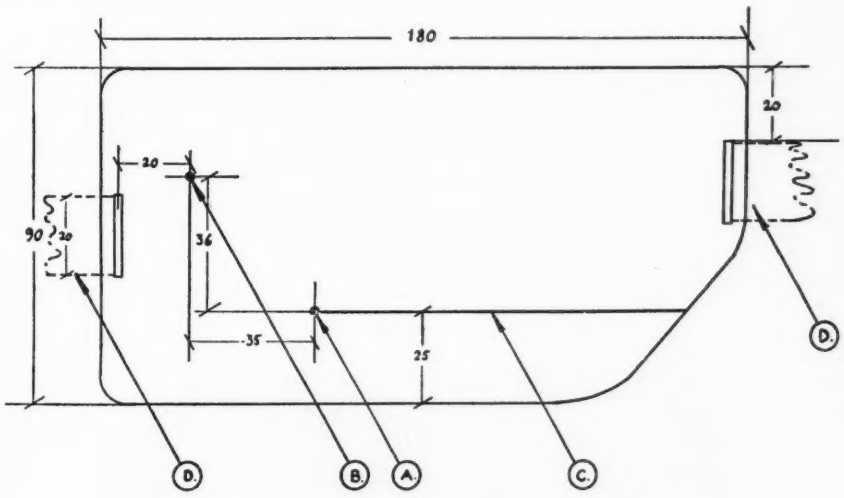


Fig. 5.—The transparent celluloid positioning device.

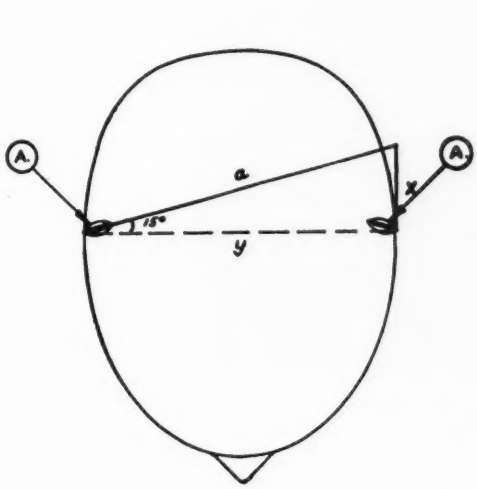


Fig. 6.

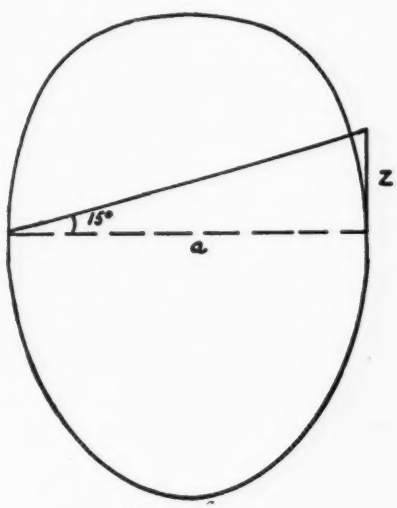


Fig. 7.

Fig. 6.—Angulation indicated on an outline of the head at the Frankfort plane. Line *a* is the direction of the central beam.

Fig. 7.—Angulation indicated on an outline of the head at right angles to the Frankfort plane at line *a*, Fig. 6.

indicator is then pushed back until the cassette touches the skin (Fig. 4). The apparatus is then in proper position for making a roentgenogram of the temporomandibular joint.

In order to locate hole *B* of the plate in relation to hole *A* (which corresponds to the condyle point), the following calculations were made. Fig. 6 represents a section of the head coinciding with the Frankfort plane. The line *y* runs from one condyle point to the other (*A-A*). This distance is in ordinary cases assumed to be 13 cm. Using trigonometrical methods we get the following formula:

$$x = 13 \cdot \text{tg } 15^\circ = 3.49$$

Fig. 7 represents a vertical section of the head at right angles to the Frankfort plane coinciding with the line *a* in Fig. 6.

The length of *a* is found as follows:

$$\cos 15^\circ = \frac{y}{a}\ ;\ a = \frac{y}{\cos 15^\circ} = \frac{13}{0.9659} = 13.45 \ldots\ldots$$

Furthermore, $\text{tg } 15^\circ = \frac{z}{a}$ $z = a \cdot \text{tg } 15^\circ = 3.60$

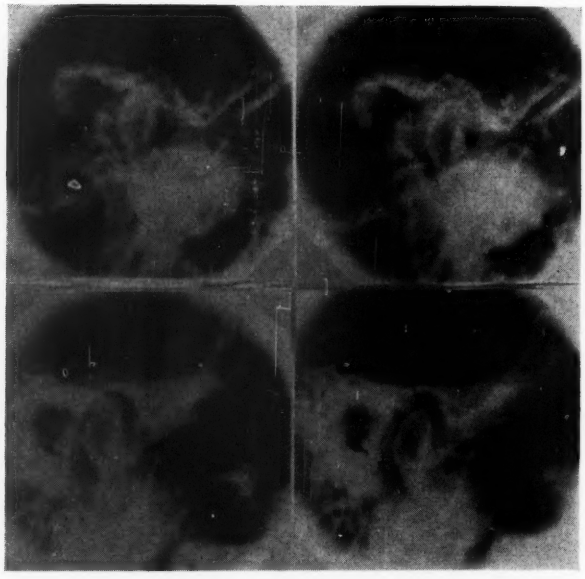


Fig. 8.—Roentgenograms of the positions of the condyles and their fossae in a patient before (left) and after (right) occlusal reconstruction.

I am fully aware that these calculations are not quite exact, but they are sufficiently exact to give a position of hole *B*. Since we are always working with the same degree of approximate accuracy, this is of no significance. We nevertheless, are able, to produce periodical pictures under identical conditions. This is of great importance when the positions of the condyles are to be controlled as in cases where an occlusal reconstruction is performed (Fig. 8).

I use a lead diaphragm with an aperture of 2 cm. in the cone. With the ordinary Ritter dental x-ray machine, the time of exposure will be about four seconds, provided that intensifying screens are used in the cassette.

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WAHRENDORFFSGATAN 4.
STOCKHOLM, SWEDEN

ANATOMIC TERMINOLOGY

JOSEPH S. LANDA, D.D.S.

College of Dentistry, New York University, New York, N. Y.

THE TREMENDOUS progress achieved in physiology in the last three decades has necessitated a readjustment of our concepts of the interdependence of structure and function in some parts of the human body from time to time. This, in turn, may suggest the desirability of modifying the nomenclature of some anatomic structures to give them names more descriptive and meaningful, from the standpoint of their physiologic function. Perhaps the term "glenoid cavity" should undergo such a change now even though this term may be appropriate in comparative anatomy. It is confusing in human anatomy. *Gray's Anatomy* defines it as follows: "The *glenoid fossa* (fossa mandibularis) is a considerable hollow formed in the front by the squamous part of the temporal, and behind by the tympanic bone."

First, the term *glenoid fossa* or *glenoid cavity* is redundancy in itself, because the word *glenoid* is derived from two Greek words: *glene* = cavity, and *eidos* = form. *Glenoid cavity* then literally translated means—"cavity form cavity"—a redundancy. Second, in the past, the anteroinferior surface of the pars tympanica of the temporal bone was not only regarded as the posterior wall of the glenoid cavity, but it was also thought that this section of the bone is pounded upon by the condyles and traumatized to the point of partial deafness and other symptoms in instances of mandibular overclosure.

It is now accepted by most authorities that the mandibular condyle, in its function, remains confined to the cavity of the *squamous portion* of the temporal bone. The boundaries of the cavity are the eminentia articularis in the front, the posterior lip and postglenoid process posteriorly, and the lateral and median lips on the sides. In addition, the space between the posterior wall of the capsule and the anteroinferior portion of the tympanic bone is filled by a part of the parotid gland. It would then seem to me that the term *glenoid cavity* could be replaced by the term *squamomandibular cavity,* and the term *temporomandibular joint* by the *squamomandibular joint.* These, in my opinion, would be more expressive designations descriptive of our present concepts of the physiologic function of the condyles within the confines of the squamomandibular cavity. It would also obviate the redundancy of glenoid cavity which literally means—"cavity form cavity."

209 EAST 23RD ST.
NEW YORK 10, N.Y.

Department of Denture Prosthesis.
Received for publication June 17, 1954.

THE LINGUAL ACCESSORY MUSCLES OF MASTICATION

HOWARD J. MERKELEY, D.D.S., M.D.S.

Winnipeg, Manitoba

IN A RECENT ARTICLE,[1] I discussed the labial and buccal accessory muscles of mastication and noted certain facts of great importance to the prosthodontist. In this article I will direct attention to the tissues on the lingual side of the lower denture.

Mucous membrane covers the floor of the mouth laterally from the side of the tongue to the gum tissue and posteriorly to the glossopalatine arch. Beneath this covering are various muscles and other tissues of interest to us.

GENIOGLOSSUS MUSCLE

In the midline superficially, we note the frenulum of the tongue. Just beneath it is the fanshaped genioglossus muscle, the extended aspect forming the vertical center mass of the tongue (Fig. 1). It is composed of three groups of fibers: the anterior, the middle, and the posterior. The anterior fibers arise from the superior mental spine; and, curving upward and backward, they form the anterior underside of the tongue as well as its tip. The middle and posterior fibers pass distally; some of the posterior fibers also pass downward to gain attachment to the hyoid bone.

The only fibers of this muscle that can, when tensed, impinge on a lower denture base are the anterior group. Tension of these muscles will curl the tongue tip down into the floor of the mouth. Protrusion of the tongue is brought about by tension of the posterior group of fibers, and none of these can impinge on a a denture base. Simultaneous tension of all three groups of fibers of this muscle curls the tongue tip downward and forces it firmly against the lingual surfaces of the lower incisors.

MUSCLES OF THE HYOID BONE

Just below the attachment of the genioglossus to the mandible, we find the inferior mental spine from which arises the geniohyoid muscle. It is a thin, narrow muscle which passes downward and backward to gain attachment to the hyoid bone. Immediately below the geniohyoid muscle in the median line, we find the mylohyoid muscle, which is a thin, wide muscle that forms the muscular floor of the mouth (Fig. 2). Each lateral half of the muscle is fan-shaped with

Received for publication June 25, 1954.

Fig. 1.—Mandible sectioned at the symphysis, left half shown, cardboard has been inserted between muscles. *M*, Mandible. *G.T.*, Genial tubercles. *M.H.*, Mylohyoid muscle. *G.H.*, Geniohyoid muscle. *H.*, Hyoid bone. *1G.G.*, Anterior fibers of genioglossus. *2G.G.*, Middle fibers. *3G.G.*, Posterior fibers of the genioglossus.

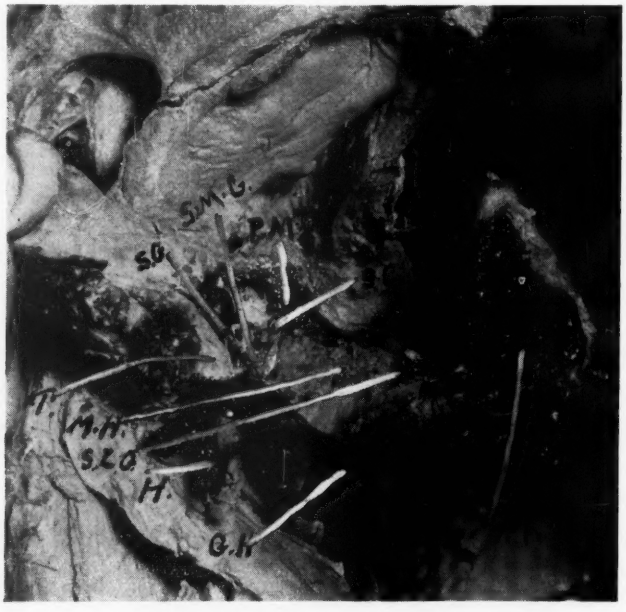

Fig. 2.—Same specimen as Fig. 1, but the genioglossus and geniohyoid muscles have been freed from their attachments to the mandible, and pushed to the right. *M.*, Mandible. *G.H.*, Geniohyoid muscle. *H.*, Hyoid bone. *S.L.G.*, Sublingual gland. *M.H.*, Mylohyoid muscle. *T.*, Tongue. *S.G.*, Styloglossus muscle. *S.M.G.*, Lobe of submaxillary gland. *P.M.*, Pterygomandibular ligament. *S.C.*, Fibers of the superior constrictor of pharynx attached to the end of the mylohyoid ridge.

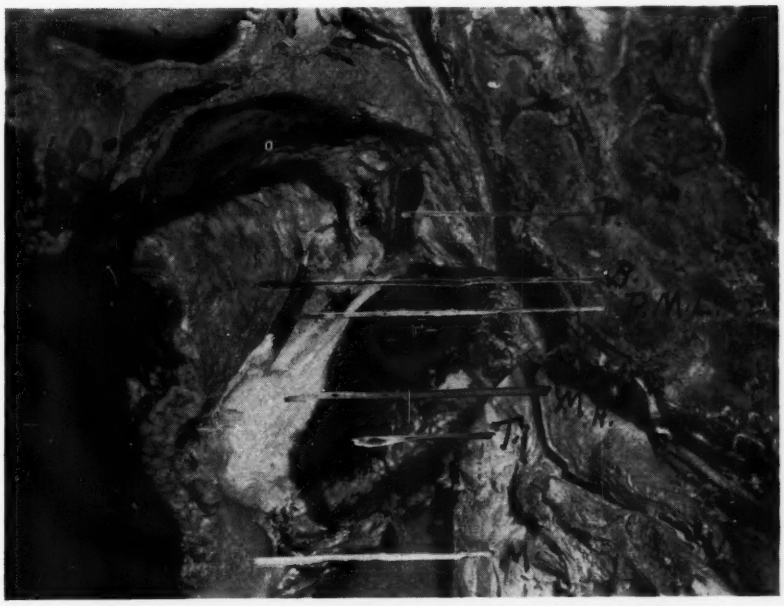

Fig. 3.—Right half of sectioned mandible. *M.*, Mandible. *T.*, Tongue. *M.H.*, Mylohyoid muscle. *P.M.L.*, Pterygomandibular ligament. *B.*, Buccinator muscle. *P.*, Palatoglossus muscle.

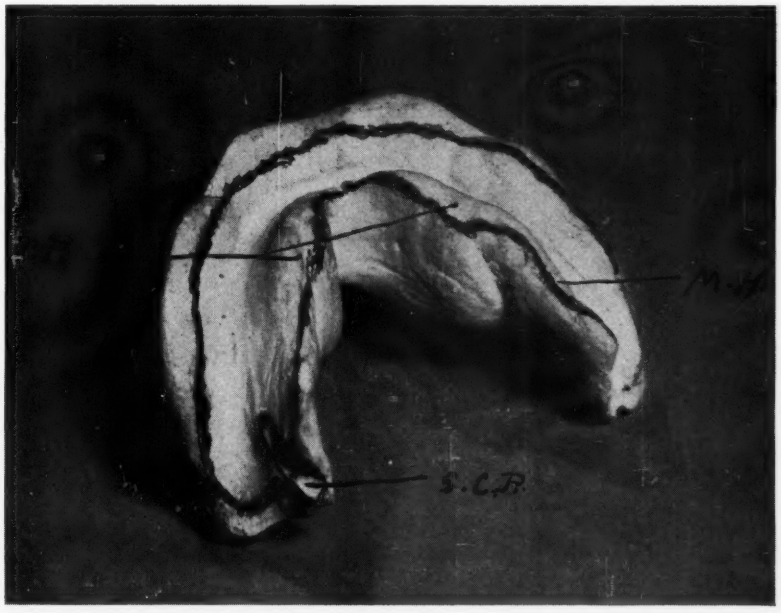

Fig. 4.—A lower thin plaster tray impression with the tray outlined. *S.C.P.*, Groove cut by fibers of the superior constrictor of the pharynx attached to the end of the mylohyoid ridge. *M.H.*, Region of mylohyoid muscle action. *T.R.*, Region for denture tongue rest.

the base of the fan attached to the hyoid bone. The extended part is attached to the mylohyoid ridge on the medial surface of the mandible back to the third molar region. In the bicuspid region, we find the sublingual gland overlying the mylohyoid muscle. If a proper impression technique is employed, this region frequently shows a place where a tongue rest for a lower denture can be provided; or we may find a crypt that will accommodate a fairly large extension downward of the lingual flange of a lower denture, thus helping greatly to ensure stability and retention. There is a wide variation in the tissue tension of the floor of the mouth even with all muscles flaccid.

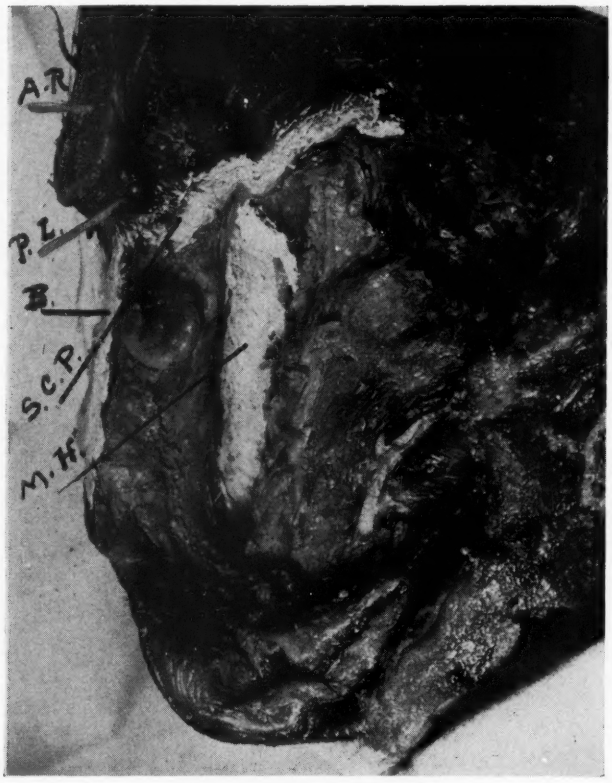

Fig. 5.—Mandible, right ascending ramus sectioned just above occlusal plane. *M.H.*, Mylohyoid muscle. *S.C.P.*, Superior constrictor of the pharynx. *B.*, Buccinator muscle. *P.L.*, Pterygomandibular ligament. *A.R.*, Ascending ramus.

As we pass distally, we find no muscles that will impinge on a denture base until we reach the region of the second molar (Fig. 3). Here the mylohyoid ridge and its attached muscles become quite superficial. Occasionally we may find a battered down ridge crest with a lingual inclination that may be, and often is, mistaken for the mylohyoid ridge. The lateral attachment of the mylohyoid muscle frequently ends in the third molar region. Also, in this area, the end of the mylohyoid ridge is very close to the crest of the residual ridge and gives

rise to some fibers of the superior constrictor muscle of the pharynx. Other fibers of this muscle arise from the pterygomandibular raphe, just above.

We have now reached the limit of our backward excursion, for here we find the anterior pillar of the pharynx formed by a mucous membrane covering over the palatoglossus muscle (Fig. 3). Deeper medially, the styloglossus muscle finds entrance to the side of the tongue, while laterally the mucous membrane covering passes over the pterygomandibular raphe and onto the buccinator muscle.

Fig. 6.—Left half of mandible swung to the left. *M.M.*, Mylohyoid muscle. *T.*, Tongue. *L.N.*, Lingual nerve. *P.L.*, Pterygomandibular ligament. *I.P.*, Internal pterygoid muscle. *M.N.*, Mandibular nerve. *M.A.*, Mandibular artery. *M.*, Bare mandible.

SUMMARY

We have now covered the circuit and found certain muscles that will impinge on the lower denture during tension (Fig. 4). In the median line the frenulum of the tongue, a fibrous cord, will need attention. Underneath it the anterior fibers of the genioglossus muscle will tense at the commencement of the act of swallowing. As we pass distally, we find no muscles until we reach the second molar region where the mylohyoid muscle becomes superficial (Figs. 5 and 6). It also is tensed in swallowing. Finally the retromolar fossa must be considered.

Fig. 7.

Fig. 8.

Fig. 7.—A roentgenogram of the tongue in rest position. Steel beads have been placed on the dorsum of the tongue, another string of steel beads has been sutured to the palatoglossus muscle; 14 mm. of beads extend backward and downward from the lower third molar. Note and compare the position of hyoid bone in Figs. 7, 8, 9, and 10.

Fig. 8.—When the tongue is protruded, the beads rise almost to the level of the occlusal surface of the third molar, but they still point downward and extend distally 9 mm. from the third molar. Note the position of the hyoid bone (floor of the mouth).

Fig. 9.

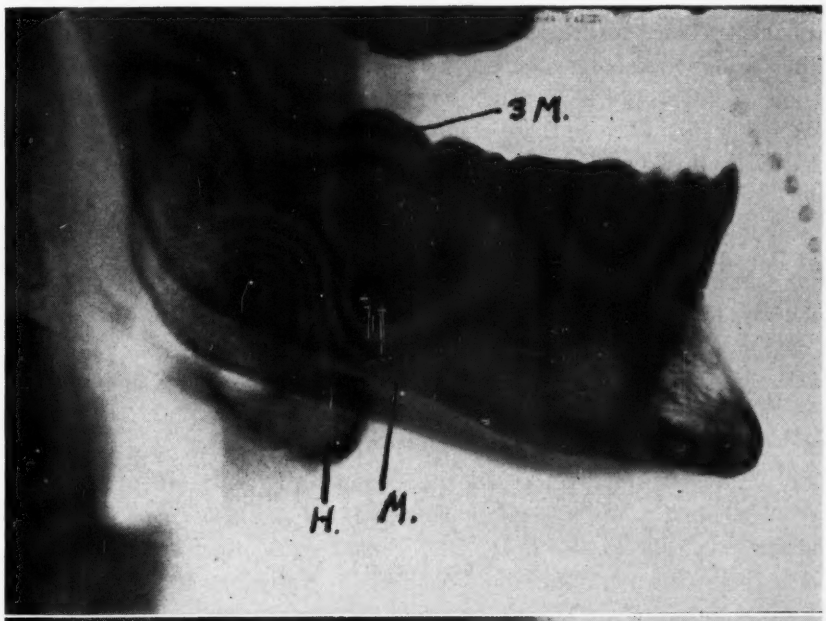

Fig. 10.

Fig. 9.—When the tongue is forced against posterior palate, 8 mm. of beads project upward and backward from the third molar. Note the position of the hyoid bone.

Fig. 10.—When the tongue is forced against the lingual surfaces of the lower anterior teeth, only 5 mm. of beads extend backward and downward from the third molar. The hyoid bone (floor of the mouth) is at its highest location.

Swallowing tenses the muscles found here. The palatoglossus and the superior constrictor of the pharynx are of interest to us. On tension, the posterior wall of the pharynx comes forward and the base of the tongue upward. In order to depict the various muscle movements, steel beads were sutured to the palatoglossus muscle, and roentgen-ray head plates were made with the tongue in four different positions (Figs. 7 to 10). In three exposures, beads were laid on the dorsum of the tongue. With this as a basis, a lower impression technique was evolved that has been quite satisfactory even in very difficult cases.

A full understanding of muscle action is very necessary if we hope to solve some of our denture problems without resort to implant or magnetic dentures.

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613 Medical Arts Bldg.
Winnipeg, Manitoba

ANATOMY OF INTEREST TO THE PROSTHODONTIST

R. T. Hill, Ph.D.*

The University of Miami, School of Medicine, Coral Gables, Fla.

THE NORMAL MANDIBLE finds the mental foramen approximately midway between the alveolar border and the lower free margin. The location of the mandibular canal has a corresponding relationship. The buccinator muscle has its mandibular attachment from the area of the retromolar triangle outwardly along the oblique line of the mandible extending as far forward as the mesial surface of the first molar tooth. The mylohyoid muscle has its mandibular attachment from the mylohyoid line, its posterior extent approximating the distal surface of the third molar tooth. The apices of the roots of the posterior molar teeth extend into the mandible, a distance which is greater than from the alveolar margin of the mandible to either the oblique line or the mylohyoid line. The apices of the roots of all of the molar teeth of the lower arch extend into the alveolar border of the mandible, a distance sufficiently great to carry them into the immediate region of the mandibular canal; a sufficient distance, in fact, so that the roots of the molar teeth may invade the mandibular canal or extend on either side of it.

Following the removal of the lower teeth, the first portion of the alveolar border resorbs very rapidly. Somewhat as a rule of thumb guide, one can say that eventual resorption of the alveolar border of the mandible carries on to a distance equal to that which contained the roots of the teeth in the normal mandible.

Following removal of teeth of the lower arch and resorption which may be stabilized more rapidly by alveolectomy, the resorption proceeds so far as to approach the mandibular canal; in fact, quite commonly the mandibular canal comes to be an open groove with no bone between the nerve and the gingiva. This is true, of course, in only part of its extent. This resorption produces a violent change in the anatomy of the mandible, and in its process leaves the mandibular attachments of the buccinator and mylohyoid muscles approximating each other in the upper posterior region of the mandible.

An artificial denture applied to the lower arch following resorption must take into consideration the proximity of those (buccinator and mylohyoid) muscles in the region of the upper posterior edentulous margin of the mandible. In the absence of proper consideration of the changes caused by resorption, the activity of the buccinator and mylohyoid muscles will impinge upon the newly applied prosthesis, causing variable degrees of irritability in the immediate surrounding tissues. The resultant irritation and discomfort often become so severe that

Read before the Academy of Denture Prosthetics April 16, 1954, Miami Beach, Fla.
Received for publication June 25, 1954.
*Chairman of the Department of Anatomy.

continuous wearing of the denture proves impossible, or the action of these muscles will not allow a continuous good seating of the denture.

Knowledge of these muscles and their actions is important to the prosthodontist, as well as the proper allowances that should be made in the prosthesis, or should be followed by a relatively simple and effective correction with resultant comfort to the patient and the increasing efficiency of the applied restoration.

ANATOMY OF THE UPPER JAW

In the normal upper dental arch, the teeth and the alveolar portion of the maxilla form a surprisingly deep concavity to the hard palate. The teeth of the upper arch have roots which extend into the maxilla a distance comparable to the depth of the concavity from the hard palate to the alveolar border of the maxilla. This peculiar arrangement of teeth in the upper arch allows the apices of the roots to lie extremely close to the floor of the maxillary antrum; in fact, it is common that the apex of some one or more teeth forms an impression constituting a miniature hillock in the floor of the antrum. In those cases, the bony material over the apex of the tooth and constituting the floor of the antrum is one and the same. These areas are paper-thin in nature. We have seen several specimens with no bone covering the apex of occasional teeth. In those instances, the apex of the teeth was separated from the cavity of the antrum only by the mucous lining of the antrum in conjunction with the periodontal membrane. In the normal mouth, the alveolar border which contains the upper third molar tooth constitutes the anterior limits of a comparatively prominent or deep notch, the posterior extent of that notch being the pterygoid hamulus. That notch is known as the hamular notch. In life, the notch is filled with mucoid gingival tissue and the tendon of the tensor veli palatini and its bursa. The function of the tensor veli palatini muscle and its tendon in the hamular notch is of prime importance for normal action of the soft palate. The maxillary boundary of the notch, the tuberosity, and the remaining alveolar border of the maxilla undergo resorption nearly as violent as the alveolar margin of the mandible. The resorption of the maxillary alveolar border reduces noticeably the anterior bony demarcation of the hamular notch.

Any prosthesis applied to the upper edentulous arch for the purposes of artificial teeth should be made in such a fashion as to allow freedom of movement of the tendon of the tensor veli palatini muscle. Any infraction on the freedom of movement of that tendon results in a condition incompatible with comfortable movement of the soft palate. Immediately medial to the alveolar border of the third molar tooth of the maxilla and at the greatest depth of the hard palate is the opening of the lower end of the pterygopalatine canal, through which emerges the greater palatine nerve, artery, and vein to supply the major portion of the hard palate. The application of a full artificial denture to the upper arch must be made with knowledge of the presence of these palatine structures and must be free from infringement on their course and function.

Of correlative interest in relation to the maxilla, the exodontist should be aware of the proximity of the maxillary antrum and of the ever-present possibility of some portion of the root of a molar tooth being pushed into the cavity of the antrum.

Following removal of all teeth in both the upper and lower arches and subsequent resorption, the mandible has a resultant overclosing when it approximates the maxilla. This overclosing is coincident with a variable degree of displacement of the condyle in a downward and backward direction from its normal position in the glenoid fossa.

RESULTS OF DISPLACEMENT OF THE CONDYLE

The mandibular division of the trigeminal nerve emerges from the skull through the foramen ovale. The foramen ovale lies immediately behind the base of the lateral pterygoid plate and at the uppermost and deepest boundary of the infratemporal fossa. As the mandibular nerve appears on the external base of the skull, it gives rise to the auriculotemporal nerve. The auriculotemporal nerve skirts the spinous process of the sphenoid bone and enters the substance of the parotid gland just below the temporomandibular joint capsule. It then proceeds laterally to become subcutaneous just anterior to the lower portion of the auricula. In the course of the auriculotemporal nerve becoming cutaneous, it innervates the temporomandibular joint capsule and the parotid gland. The overclosing of the edentulous mandible, as it approximates the edentulous maxilla, subjects the temporomandibular joint capsule to possible trauma and resulting tenderness and extending symptoms. Direct impingement upon the nerve by the misplaced condyle is not impossible. The involvement of the joint capsule and the auriculotemporal nerve may give rise to referred pain to the tongue by way of the lingual nerve and thus be a causative agent in the condition sometimes known as Costen's syndrome.

Department of Anatomy
University of Miami, School of Medicine
Coral Gables 34, Fla.

PROSTHETIC TREATMENT OF MAXILLOFACIAL INJURIES

LIEUTENANT COLONEL EDWIN H. SMITH, JR., D.D.S., M.Sc.D.*

Walter Reed Army Hospital, Washington, D. C.

THE INJURIES TO THE face and jaws caused by bullets and shell fragments during armed conflict present the medical and dental professions with severe problems. The public's constant desire for speed has been responsible for supplying a projectile every bit as lethal as any of the more modern artillery shells. These high speeds are resulting in automobile accidents which produce severely disfiguring injuries of the jaws and face.

The maxillofacial injury sustained by a person in an automotive accident differs considerably from the injury caused by a shell fragment or bullet. The former injury is a crush type of wound, which is seldom as extensive as the wound caused by a projectile. This injury is manifest by multiple comminuted fractures, great displacement of the fragments, severely bruised or torn soft tissues but rarely with any soft tissue loss.[7, 12, 19] The projectile type of wound, on the other hand, has grossly comminuted compound fractures with loss of osseous and soft tissue. The entrance wound is small. As a result of the penetration, the bone is comminuted and carried, with the projectile, into the soft tissues causing gross destruction. The exit wound is usually large, with extensive tearing and loss of tissue.[7, 12]

Despite the differences between the wounds, the basic treatment plans are the same. Consequently, the problems of management and treatment of maxillofacial injuries are becoming of more concern to all of us in the profession. The title of this presentation, "Prosthetic Treatment of Maxillofacial Injuries," covers a tremendous field of prosthetic endeavor. For anyone to attempt to cover such a vast area in a short presentation would be impossible. This discussion will be limited, therefore, to the prosthetic evaluation and treatment of those casualties whose injuries were sufficiently severe to require evacuation to mainland installations for extensive plastic and maxillofacial surgery. The discussion deals with those intraoral appliances constructed as an adjunct to the surgery, and the subsequent prosthetic placements.

The majority of these casualties are successfully managed overseas. Only a small proportion of those wounded are evacuated to the mainland for treatment. Kazanjian[9, 10] and Padgett[13] have stressed the necessity for efficiency and simplicity of appliances, speed of immobilization, and rapidity of treatment of maxillofacial injuries. The more adequate the initial treatment, the easier and less complicated the subsequent surgery.

The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Army Dental Corps.

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 16, 1954.

Received for publication June 12, 1954.

*Chief, Prosthetics Section, Dental Service.

Occasionally these casualties have suffered other injuries which make it imperative that repair of the maxillofacial injuries be delayed until the patient is physically able to receive definite treatment. Pound[15] expressed it when he said that the idea uppermost in the minds of all is that the patient's life is of more importance than the immediate treatment of his wounds. Generally, maxillofacial casualties[14] received excellent early care by immobilization of bony structures, debridement, and closure of wounds, and control of infection by administration of chemotherapeutic agents. Occasionally, the immediate repair of the maxillofacial injury was delayed by other injuries and a less well-treated patient was received.

I would like to stress the fact that in the treatment of these casualties, sections of both the Surgical Service and the Dental Service collaborate. It is only by close cooperation, mutual trust, professional respect, and complete understanding among the services that the patient can receive the maximum benefits.

The various members of the maxillofacial team[16] should not be embarrassed by the special knowledge of the other members in their special fields of endeavor. Common principles should be the basis of approach. In the elaboration of the treatment plan, the plastic and oral surgeons must know what can be expected of their prosthetic colleagues. They must appreciate the prosthetic problems, and just what can or cannot be accomplished. Simultaneously, the prosthetic team member must understand the principles and plans of the surgeons as well as to know exactly what is expected of the appliances.

I feel that a prosthetist should be a part of the maxillofacial team. The prosthetist will see and request things from a restorative standpoint that may be overlooked by the other members of the team. In addition, I feel that he is probably the most qualified to make impressions of the mouth, and, in conjunction with the maxillofacial surgeon, to design the splints and other appliances necessary for stabilization. By overlooking the services of the prosthetist, the surgeon assumes many responsibilities and headaches that he may not be as well qualified to handle as the prosthetist.

It is my belief that the prosthetist carries three responsibilites in the treatment of these wounds. The first is to himself. His understanding and treatment should be an aid and adjunct to the surgeons involved. In consultation with the oral surgeon and plastic surgeon, a determination of the extent of the bone and soft tissue involvement should be made. The entire surgical treatment plan for the patient should be clearly outlined by the surgeon, and completely understood by the prosthetist. It is only then that he will be able to contribute his maximum efforts to the construction of the proper alliances. Then satisfactory splints and stents can be constructed that will be adaptable to subsequent operations and adequately stabilize bone and soft tissue for surgery.

His second responsibility is to the surgeon for the construction of those appliances which will stabilize and support soft and osseous tissues. There are many variations of splinting advocated today. Most surgeons have definite preferences. It is advisable that the prosthetist be familiar with the various methods of splinting so that the simplest appliances possible will be constructed to adequately satisfy the requirements of the surgeon as well as the needs of the patient.

The prosthetist's third and most important responsibility is to the patient. The appliances which offer the maximum comfort and efficiency for the patient during the surgical rehabilitation must be constructed. Subsequently, it is necessary for him to construct intraoral prostheses that re-establish tissue contour, stabilize unsupported tissues, re-establish comfortable mastication, and restore esthetics.

TYPES OF SPLINTS

Resin Splints.—Let us now direct our attention to the various methods of splinting, the construction of the splints, and their advantages and disadvantages. The first splint to be discussed is the wing type resin splint (Fig. 1). This splint is easily fabricated, offers no occlusal interference, and is economical. Unfortunately, the disadvantages of the resin splint far outweigh any advantages when they are used as a support for the stabilization of fragments during bone grafting. This splint does not give absolute fixation of the parts, is bulky, is not easily adapted to any other attachments, and accumulates food debris between the teeth and the splint. Colonel Caldwell[2] states that this splint "is no longer acceptable when used as a method of stabilization for protracted periods of treatment."

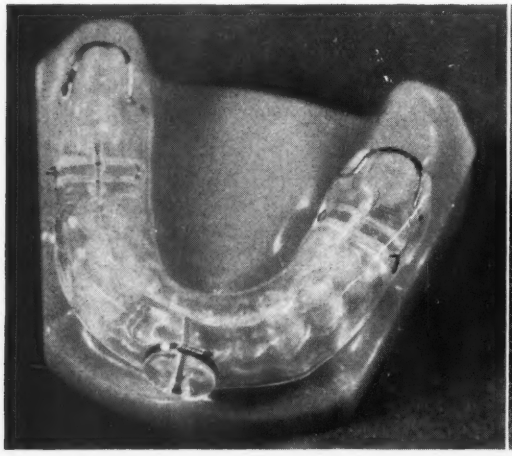


Fig. 1.

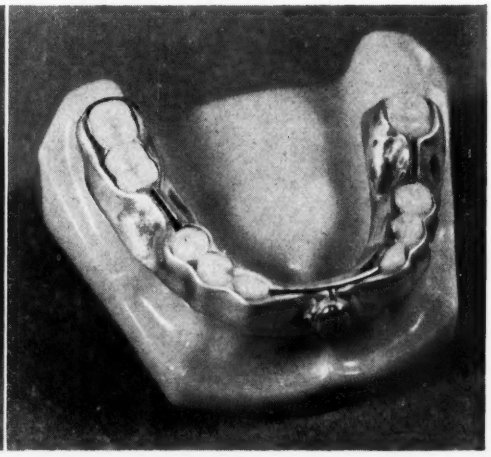


Fig. 2.

Fig. 1.—A wing type resin splint. This is the splint that is no longer acceptable as a method of immobilization for periods of protracted treatment.
Fig. 2.—A wing type cast silver splint.

Cast Silver Splints.—The wing type cast silver splint is similar in construction to the resin splint (Fig. 2). It is less bulky, stronger, and gives more secure fixation than the resin splint and offers no occlusal interference. It takes slightly longer to fabricate this type of splint, however, and food tends to accumulate between the splint and the teeth. This disadvantage can be offset by cementing the splint in position. Cement is much more likely to hold to the silver splint than to the resin splint.

The cast silver cap splint (Fig. 3), developed in the first World War and used extensively by the British during the last war,[5, 12] is an excellent method of splint-

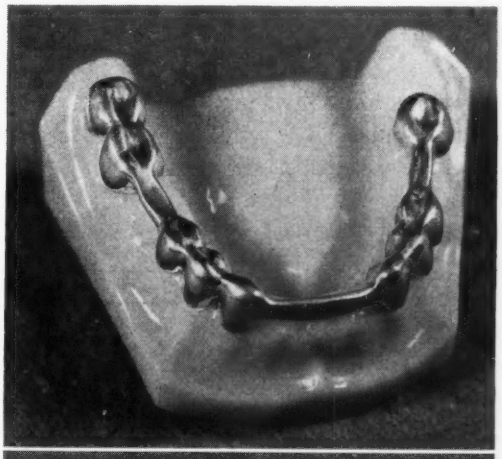


Fig. 3.

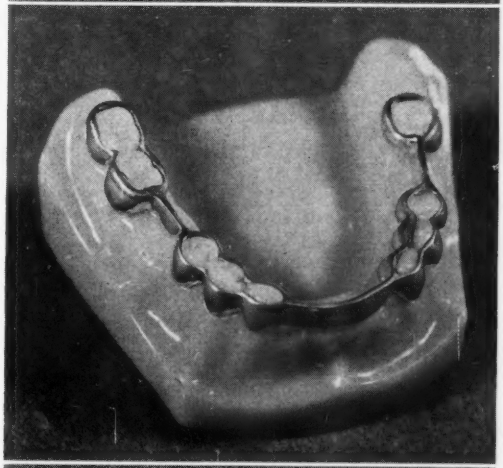


Fig. 4.

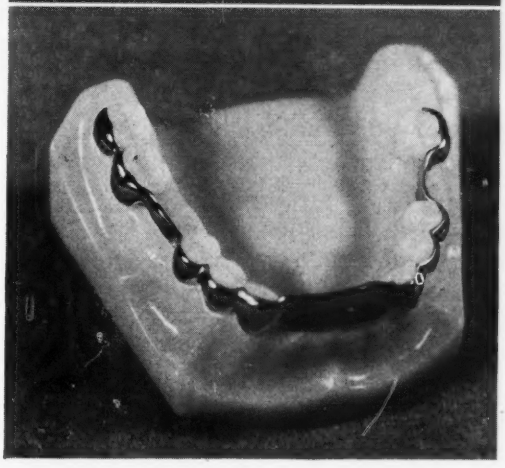


Fig. 5.

Fig. 3.—A cast silver cap splint.
Fig. 4.—An open ferrule cast silver splint.
Fig. 5.—A cast labial splint.

ing. The impressions can be made in either alginate type hydrocolloid, plaster, or modeling compound. After waxing, these splints are carefully teased from the cast so that the undercuts are relieved in the wax and no duplication is necessary. They offer a minimum of bulk, absolute fixation when cemented into position, are easily adapted to various situations, and their construction is not complicated. They have the disadvantage of interfering with the occlusion, and preventing the proper interdigitation of the teeth. The authors who have written concerning their use have stated that this feature is greatly magnified, and in no instances did gross malocclusions develop.[6]

The open ferrule cast silver splint[8,18] is constructed in the same way as the cap splint (Fig. 4), but the occlusal surfaces of the teeth are not covered. It has the additional advantage of giving a minimum of occlusal interference while affording excellent positive fixation. These splints are particularly effective when only a minimum of natural teeth remain for support of the splints.

Cast Labial Splint.—The cast lingual, or labial, splint is used when there are a number of natural teeth present in the arch (Fig. 5). The construction takes no longer than the other splints, and the bulk is considerably reduced. In properly selected cases, the positive fixation is in no way impaired. This splint, with modifications, is the type now in use at Walter Reed Army Hospital.

DIAGNOSIS AND TREATMENT

Occasionally, fixation takes place prior to the proper positioning of the fragments, resulting in malposition and malocclusion. In these instances, it is necessary to evaluate the surgery necessary to properly reposition the fragments against the cosmetic result. If the occlusion is such that adequate prosthesis cannot be constructed or will be difficult, another factor in evaluation is considered. Frequently, it is necessary to reposition the posterior fragment of the injured mandible by re-establishing the length of the body of the mandible with a bone graft. This bone graft re-establishes the proper position of the ascending ramus. Splints of the labial variety can be utilized when there are an adequate number of teeth for support.

The patient may have a disfiguring extraoral cosmetic result with the occlusion such that a satisfactory appliance could not be constructed (Fig. 6). Since the cosmetic result could be improved, and the occlusion corrected at the same time, it was decided that the fragments should be repositioned with a bone graft. A mandibular splint is unnecessary, as there is an adequate natural dentition. The maxillary splint has an occluding area built in the edentulous region to support the lower teeth. A combination labial and lingual splint, held together firmly with small bolts, was constructed. The final result permitted the construction of a satisfactory prosthetic replacement.

Grid Splint.—The final splint to be discussed is the cast grid splint (Fig. 7). This splint offers ease in construction, ease of impression making for fabrication, ease of application, strong and rigid support, simplified mouth hygiene, and lack of bulk which allows greater comfort for the patient. There is also greater ease of adaptation to the various types of construction necessary, which allows a

definite treatment plan for the solution of the various problems encountered. The splint receives its support from all of the remaining natural teeth, and very little occlusal interference is encountered.

The impressions are made in an alginate type hydrocolloid impression material and stone casts are made. Usually, it is impossible to get a full tray in the mouth. It is necessary to make impressions of sections of the mouth either in crown and bridge trays or in trays constructed at the chair. The splints are waxed on the stone cast, removed, and cast. They are cast in gold because this material has adequate strength without bulk. Silver does not possess these qualities. Stainless metals do, but the complicated casting technique and polishing have made them impractical.

A single band of 18 gauge round wax is adapted on the lingual surfaces of the teeth, and a double band with supporting struts is adapted upon the buccal surfaces of the teeth. The struts give additional strength, and are used for wiring the splints in the mouth. Spruing of this splint is very important. Heavy sprues are used so that an adequate bulk of gold is thrown into the heated mold in order to ensure a full casting. The "waxed up" splint is carefully teased from the cast, invested in a suitable refractory material, and cast. The wax pattern is lifted from the master cast to relieve the undercuts on the teeth as the wax is carefully raised over them.

The grid splint is wired in the mouth in the following manner:

a. A stainless steel wire is passed from the buccal to the lingual surface through the distal interproximal space.

b. The buccal end of the wire is passed mesially between the supporting strut of the grid splint and the tooth.

c. The lingual end of the wire is brought along the lingual side of the tooth and passed to the buccal surface through the mesial interproximal space. The wire extends around the tooth beneath the height of contour and engages the grid splint under the supporting strut.

d. The two ends of the stainless steel wire are twisted in the mesial interproximal space until the grid splint is held firmly in position. Enough teeth are wired in this manner to stabilize the splint adequately.

If sufficient natural teeth are in the opposing arch, multiple loop wiring on the maxillary teeth and intermaxillary wires may be used to fix the maxilla and mandible together. Otherwise, maxillary and mandibular splints have to be constructed. The splints can be fastened together by intermaxillary wiring or with the use of pin and tube fixation (Fig. 8). The latter method is the one of choice when general anesthetics are used.

TREATMENT OF SPECIFIC INJURIES

Frequently, shell fragments or bullets cause compound, comminuted fractures, with loss of bone at or near the symphysis of the mandible. In some instances, the mandibular arch collapses and cicatricial tissues prevent the proper positioning of the fragments (Fig. 9). Expansion of the collapsed mandible, until the teeth in right and left fragments are in proper occlusion, may be necessary before any plastic surgery can be instituted. An expansion grid splint is constructed, and traction

across the expansion arms is applied to properly position the two parts of the mandible. Slight elastic traction accomplishes this movement in a surprisingly short time, and with very little discomfort to the patient.

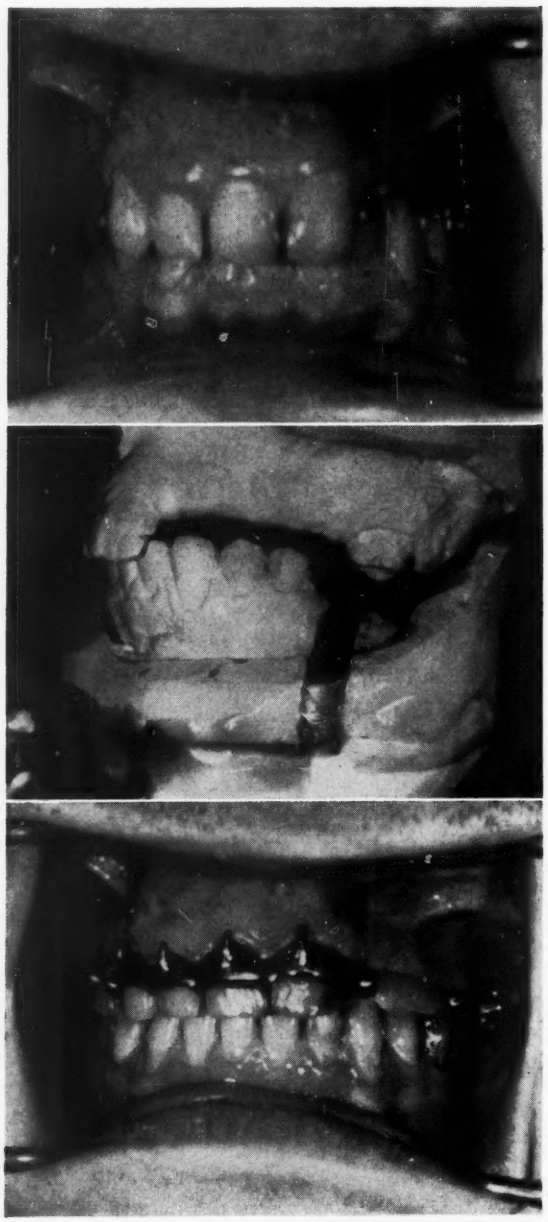


Fig. 6.—Steps in the correction of a malposed mandibular posterior fragment with resulting malocclusion.

A. Malocclusion resulting from an improperly positioned mandibular fracture.
B. Assembled casts positioned in the desired corrected relationship.
C. The maxillary splint constructed to support the repositioned mandible.

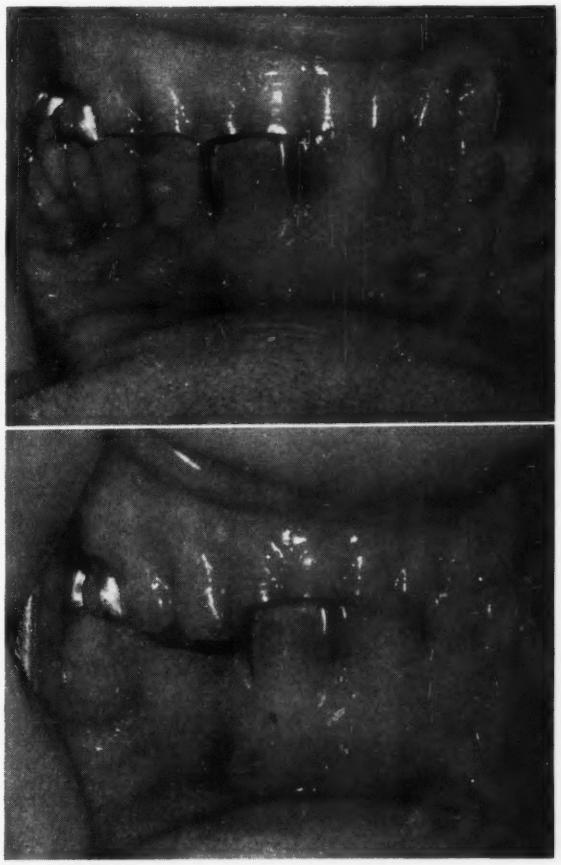


Fig. 6. *(Continued.)*
D. The occlusion after surgical correction of the malpositioned fragment.
E. The partial denture constructed as a replacement for missing teeth.

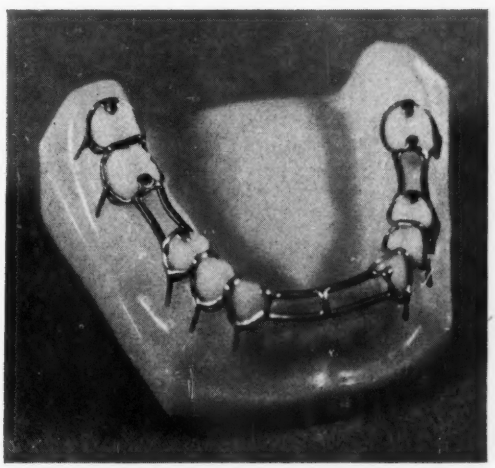


Fig. 7.—A cast grid splint.

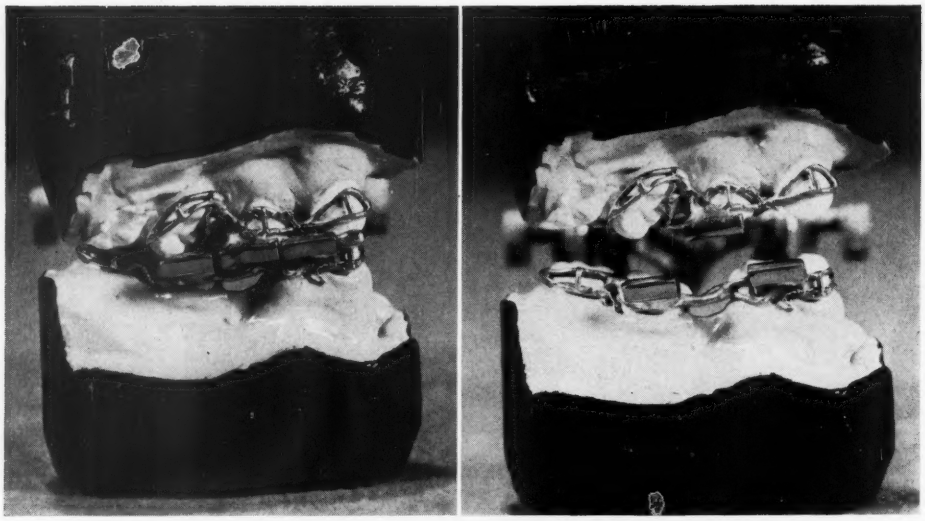


Fig. 8.—Cast grid splints with pin and tube intermaxillary fixation.
A. Locked in occlusion with pin.
B. Unlocked.

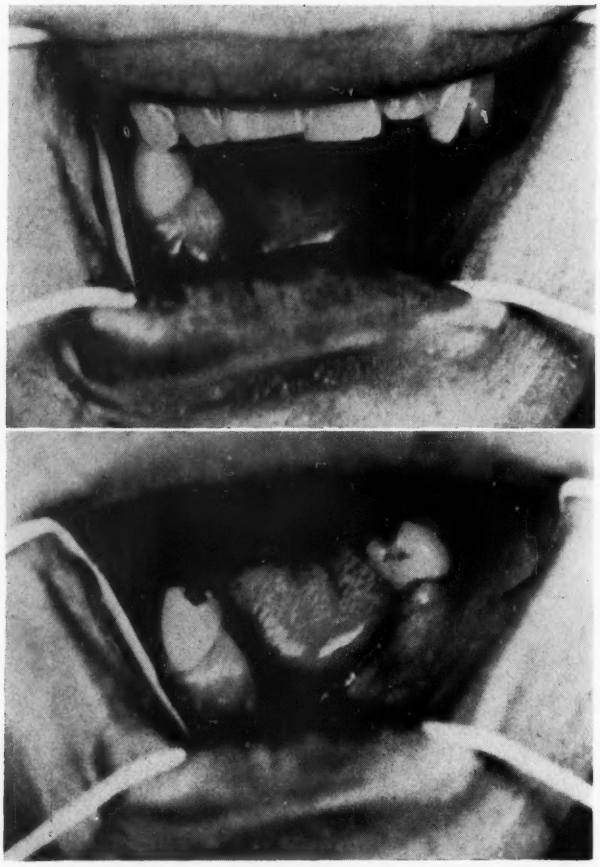
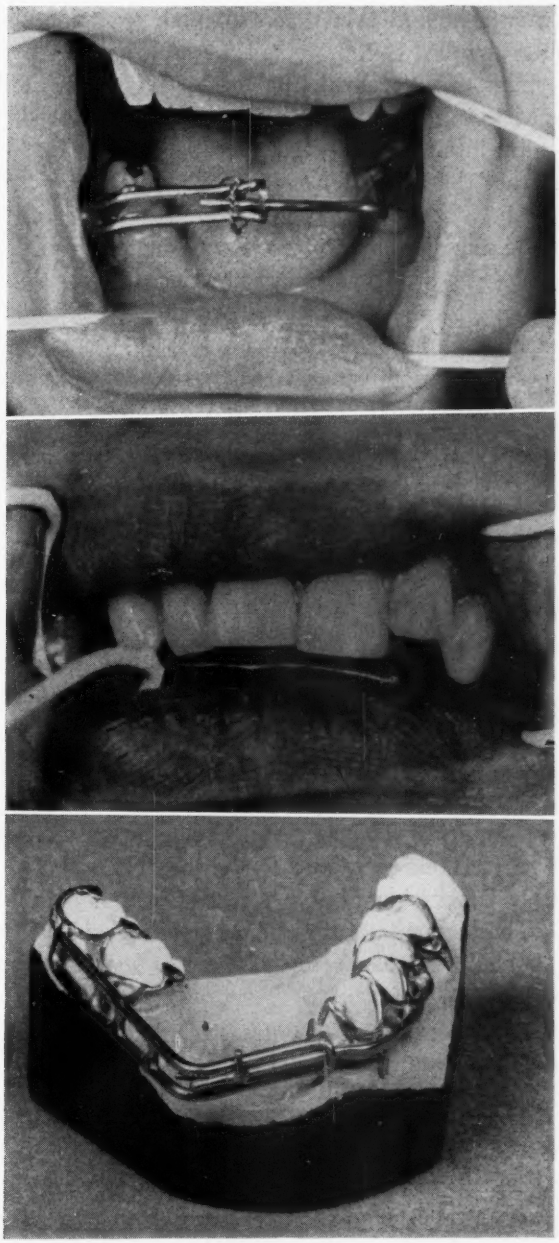


Fig. 9.—Collapse of the mandibular arch following an injury at the symphysis. Cicatricial tissues prevent the proper positioning of the fragments.
A. The occlusion prior to expansion.
B. Mouth open, showing lingual collapse of the left fragment.

As soon as the fragments are properly positioned, a one-piece plaster impression of the buccal and labial alignment of the splint is made, while the proper position of the fragments is maintained by the occlusion of the teeth. The impression is removed from the mouth, the expansion splint removed from the teeth and carefully reassembled in the impression, and a refractory cast is made. The expansion arms are removed, and a rigid splint is constructed by soldering two



C.

D.

E.

Fig. 9. ***(Continued)***

C. **The fragments after repositioning with an expansion splint.**
D. **The rigid splint following the removal of the expansion arms.**
E. **The expansion splint on a demonstration model.**

reinforced 14 gauge pieces of wire between the two segments of the splint. These operations must be accomplished rapidly, while the patient waits in the clinic, so that it will be possible to reposition the assembled rigid splint on the teeth. If the patient is permitted to be without the splint for as long as five or six hours, it will be impossible to reposition the rigid splint in the mouth. Then expansion by elastic traction would be necessary again to position the fragments.

Frequently, adequate stabilization of the right and left mandibular fragments during overseas treatment and evacuation maintains good occlusion of the teeth. A segment of the grid splint is constructed for each half of the mandible, and the segments of the splint are placed on the teeth. The right and left sides of the mandible are placed in the desired occlusion. The technique for uniting the two segments of the splint into a rigid appliance is the same as that followed in making a rigid appliance from the expansion splint. If necessary, a splint is constructed for the maxillary arch.

If maxillary and mandibular splints are constructed, it is possible to use a pin and tube for fixation (Fig. 8). The splints are placed in position in their respective arches and the teeth are brought into occlusion. A plaster impression of the buccal and labial relationships of the splints is made. Both splints are properly oriented in the impression, and a refractory cast is made. A tube is soldered to the mandibular splint in one area and to the maxillary splint in two places. The tube is then cut between the soldered joints.

This method of fixation has several advantages. The splints can be locked together during the operation, and unlocked for the short time that the patient might be nauseated during recovery. They can be locked together by the insertion of the pin into the tube. The tubes will not slip, and the pin will not permit them to come apart. If necessary, the splints can be separated easily without removing the connecting wires.

Another common gunshot injury is a fracture of the body of the mandible with loss of bone at the site of the fracture, and with a tooth or teeth in the posterior fragments. If there is a single tooth in the posterior fragment, the tooth is crowned and the occlusal surface is left open. A grid splint is constructed for the remainder of the arch. If there is more than one tooth in the posterior fragment, a segment of the grid is constructed. The anterior segment of the splint and the crown are placed on their respective teeth, properly occluded with the maxillary teeth, and a plaster impression of the buccal alignment is made while the teeth are in occlusion. The segments of the splint are reassembled in the impression and a refractory cast is made. Solder connects the two segments with 14 gauge round wire (Fig. 10).

STENTS FOR SKIN GRAFTING

Quite frequently, after bone grafting has been accomplished, it becomes necessary to re-establish a buccal sulcus. This is best accomplished by the use of a split-thickness, or Thiersch skin graft.[3] These grafts have to be held in position while adequate nourishment for vitalization is received from the prepared site, and then maintained in a stretched position for several months to prevent contraction. This can be accomplished with a splint (Fig. 11) or with a modified denture.

TRISMUS

Occasionally, due to injury to the muscles of mastication, injury to the temporomandibular joint, and associated structures, or scar formation, trismus develops. The principle difficulty encountered in the treatment of this condition is in having the patient open his mouth sufficiently wide to permit the making of an impression of the teeth. The patient is instructed in the use of tapered rubber corks, of gradually increasing size, until sufficient space to permit the making of an impression is obtained. Usually it is necessary to use an absolutely flat piece of metal as a tray. No provision is made for holding the alginate type hydrocolloid to the tray. After the impression material has set, the flat tray should be carefully removed, and the impression material left around the teeth. The impression is carefully teased out of the mouth in one piece, and reassembled on the flat tray. A stone cast of the teeth, only, should be made, and a base for the cast built.

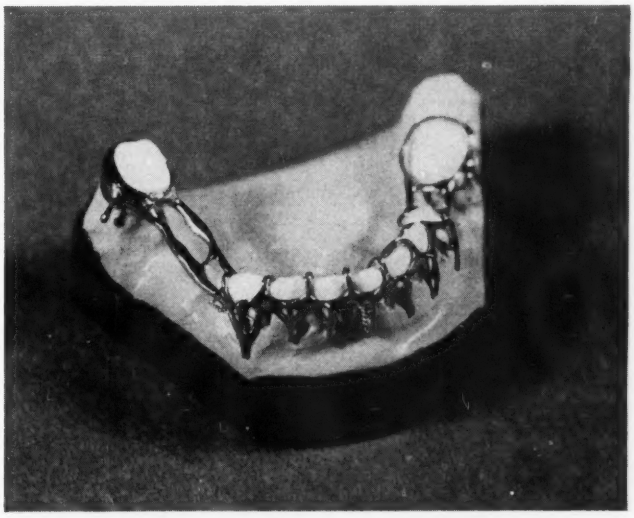


Fig. 10. *A.* A grid splint utilized for support of a fracture with loss of bone in the body of the mandible, with a tooth in the posterior fragment.

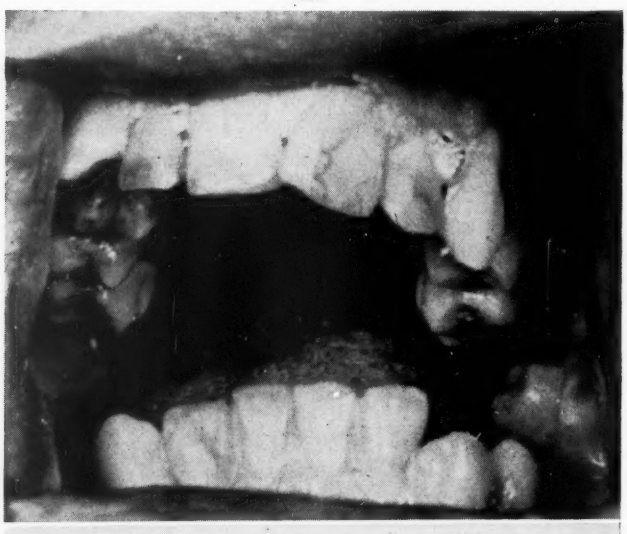
This cast is sufficiently accurate to permit the construction of the splint. The casts are mounted in occlusion on a hinge articulator. Splints are constructed and lateral arms are attached (Fig. 12). These arms extend downward from the maxilla and upward from the mandible. This allows for the application of as much elastic traction as is necessary to overcome the trismus. The forces are exerted intraorally, allowing almost direct action against the muscle pull. Stresses are exerted upon all of the teeth, giving a more even distribution of the forces among all of the teeth.

PARTIAL DENTURES

We will now consider the partial denture replacements for these maxillofacial wounds. The approach to the construction of these restorations is the same as any

good sound partial denture technique. Not too much stress can be placed upon the necessity of a thorough oral examination. The proper clinical evaluation and roentgenographic examination of the condition of the teeth, and oral tissues, and the available ridge support must be carried out.

B.



C.

Fig. 10. *(Continued)*

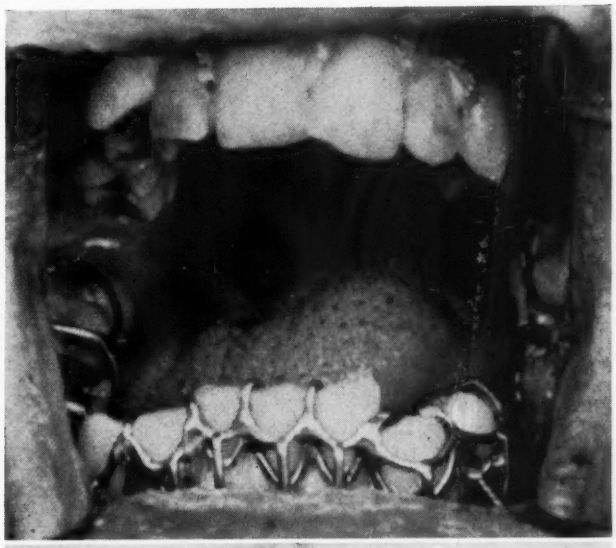
B. An intraoral view of the loss of bone in the body of the mandible. Note the forward movement of the tooth.

C. A lateral roentgenogram showing the loss of bone in the body of the mandible, and the forward movement of the posterior fragment. The mandibular left second molar was extracted prior to splint construction.

Adequate study casts must be made. They should be mounted, by the use of a face-bow if the Hanau articulator is used, or by any other suitable method with the instrument of choice in centric relationship. This centric relationship record

must be made with no occlusal interferences to prevent condylar displacement by malposed teeth or interfering cusps. These repaired injuries have usually resulted in some discrepancies between centric relationship and centric occlusion.

D.



E.

Fig. 10 *(Continued)*

D. **The intraoral splint maintaining the posterior fragment in the proper posterior position.**

E. **A lateral roengenogram showing the bone graft and splint maintaining the posterior fragment in the proper posterior position.**

Equilibration of the occlusion must be accomplished prior to denture construction. Quite frequently, crowns must be constructed so that the proper vertical dimension is maintained.

In addition to aiding in the interpretation of occlusal interferences, the study casts are utilized in designing the partial denture. The casts are carefully surveyed with the four principles of good clasping design kept in mind. Support, bracing, stabilization, and retention should be used as guides. In these patients, it is felt

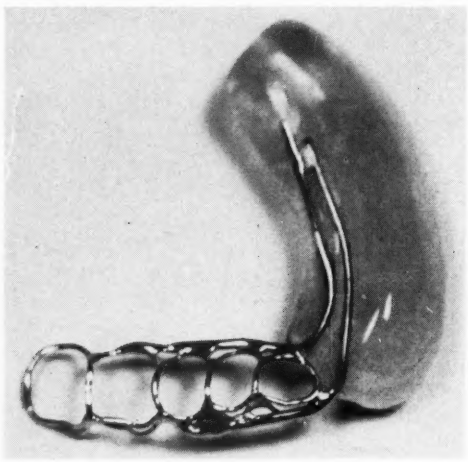


Fig. 11.—A stent for maintaining the stretched condition of a Thiersch skin graft.

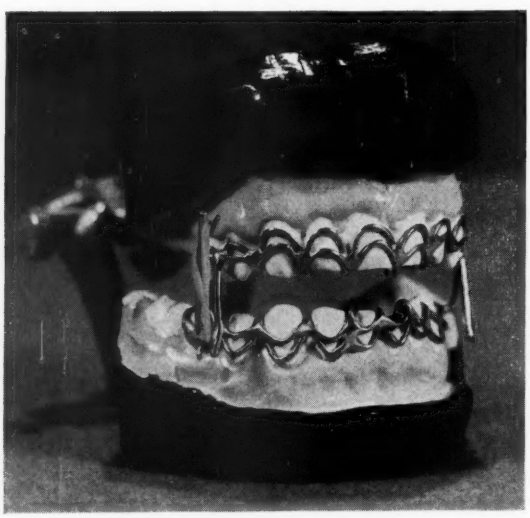


Fig. 12.—An appliance for application of elastic traction in the treatment of trismus following an injury.

that more teeth than would normally be utilized should be involved with clasps and rests so as to distribute the additional stresses among more teeth. These partial dentures should be rigid in construction so that stresses exerted on any portion of the appliance will be distributed throughout the entire partial denture.

This type of denture construction results in an appliance that will function similarly to a fixed bridge in that the teeth will carry the majority, if not all, of the stresses exerted on the appliance. It is felt that the injured or grafted bone will not withstand the stresses imposed upon it as well as the normal alveolar ridge, and consequently, some method of preservation must be instituted.

Occasionally the loss of any of the remaining teeth will result in a condition so difficult to overcome that the construction of a satisfactory prosthesis becomes almost impossible. In these instances, a compromise in the direction of tooth preservation is indicated. Thus, serious consideration should be given to the construction of some form of stress-breaking appliance.

Usually the construction of crowns is necessary to restore lost tooth structure, supply undercuts in desirable areas, or to realign and reposition malposed and maloccluded teeth. These restorations are constructed with adequate rest seats in the proper positions, with undercuts established in accordance with the dictates of the needs of the partial denture design. More than merely good operative restorations are needed. Operative restorations dictated by the prosthetic requirements must be constructed.

Sound vital teeth that are malposed or in malocclusion should be extracted only as a last resort. Teeth that might normally be considered for removal are retained to help lessen the stresses imposed upon the other teeth. Teeth in the opposite arch that are out of the plane of occlusion, or whose position will exert extra pressures and stresses on the denture, should be considered for extraction.

Each patient presents a challenge. Each treatment plan is like all others, and at the same time unlike any other. When one has worked with these handicapped individuals, with their magnificent morale, their desire to cooperate, and their appreciation, one finds the treatment of routine prosthetic patients no less exacting and vital, but certainly more vexing and less satisfactory.

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Walter Reed Army Hospital
Washington 12, D. C.

A MECHANICAL DEVICE FOR DUPLICATING A MIRROR IMAGE OF A CAST OR MOULAGE IN THREE DIMENSIONS

JEROME C. STRAIN, D.D.S.*

University of California, College of Dentistry, San Francisco, Calif.

THE RESTORATION of portions of the body contours and anatomy through surgery is oftentimes not indicated and occasionally impossible. Very often the surgeon or his assistants have tried to bolster up the courage of the patient prior to surgery by telling him that the defect can be restored to normal appearance or function through reconstructive surgery or by a prosthetic appliance. Occasionally this is a misconception and leaves the patient very much disappointed. It is possible, however, to assist these individuals materially through the use of a prosthetic appliance when it is necessary. Those who seek the services of a prosthetist usually do so with one purpose, a cosmetic result, uppermost in their minds. Fortunately for the prosthetist, the two halves of the body are not exact duplicates. This, however, does not make the task much easier. The prosthetist is still faced with the problem of detailed sculpturing of the defective part.

METHODS OF CONTOURING MISSING PARTS

There are several ways of duplicating or contouring a defective or missing part of the surface anatomy.

1. By making an impression of a member that closely resembles the missing part and adapting it to position.
2. By making an impression of the defective area and a working cast. The defective part is recontoured upon this cast. The sculpturing is done in the usual manner.
3. By a combination of the first two methods.
4. By making an impression of the defective area prior to surgery and adapting the pattern to the body surface.
5. By the duplication of the patient's opposite side through the use of the third dimensional pantograph.

When the member is missing in toto, such as an ear, it is relatively easy to find one of our acquaintances who has an ear of the approximate size and shape of that of the patient. With his or her permission, we can then duplicate it and adapt it to our purpose.

If parts remain and we wish to build up the missing parts meticulously, then it is very convenient to have a device which will aid us in establishing the proper contours. We have been able to do this through the use of an instrument, con-

Received for publication June 14, 1954.

*Assistant Clinical Professor. Denture Prosthesis and Oro-facial Prosthesis.

structed by us, which I call a "third dimensional pantograph" (Fig. 1). An attempt was made to find such an instrument but to no avail.

The objective was to devise an instrument which would aid us in building a prosthesis when we have a cast to serve as a model. The instrument must be capable of applying the measurements in reverse so that the left side can be recontoured, using a cast of the right side as the model. Valuable assistance was rendered by Mr. Harry L. Roderick in the initial phases of development of this instrument.

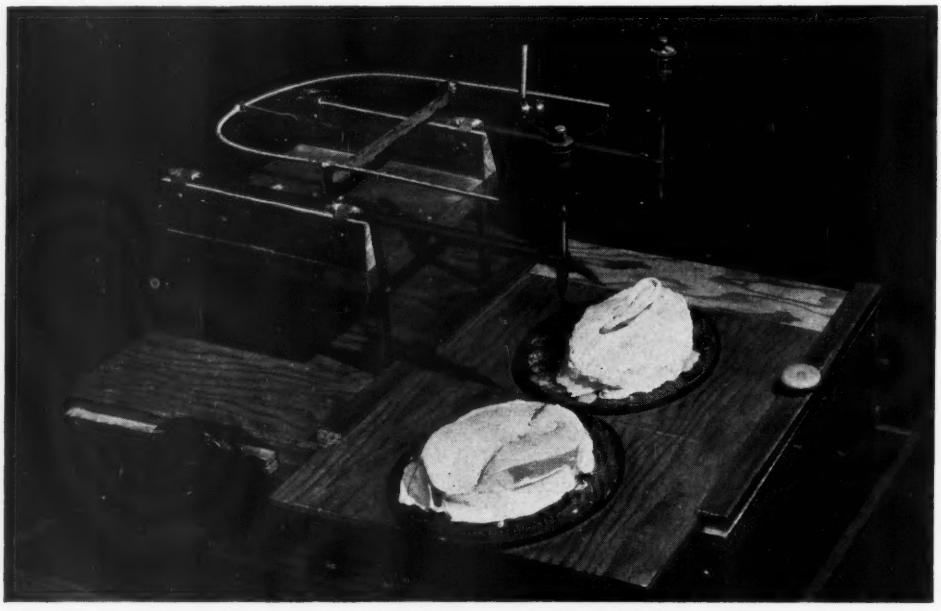

Fig. 1.

THE THIRD DIMENSIONAL PANTOGRAPH

An instrument was constructed which would actually allow us to build a mirror image in three dimensions, using a cast of the opposite side as a guide for carving the pattern for the restoration. One stylus would contact the surface of the cast which serves as a model while the other stylus is used as a carving instrument (Fig. 2).

The instrument consists of a platform with two revolving tables (*A*) on one side and the control levers (*B*) on the other (Fig. 3). The two revolving tables are mounted on a sliding panel (*C*) controlled by a rack and pinion gear (*D*). A dental handpiece (*E*) was positioned at the end of each of the levers (*B*). The handpiece acts as a chuck for the various sculpturing or measuring instruments that we wish to use. A connecting piece (*F*) controls the thrust in the forward and backward direction, and the cable (*G*) controls the thrust in the other direction, as well as limiting the movement of the chucks or handpieces.

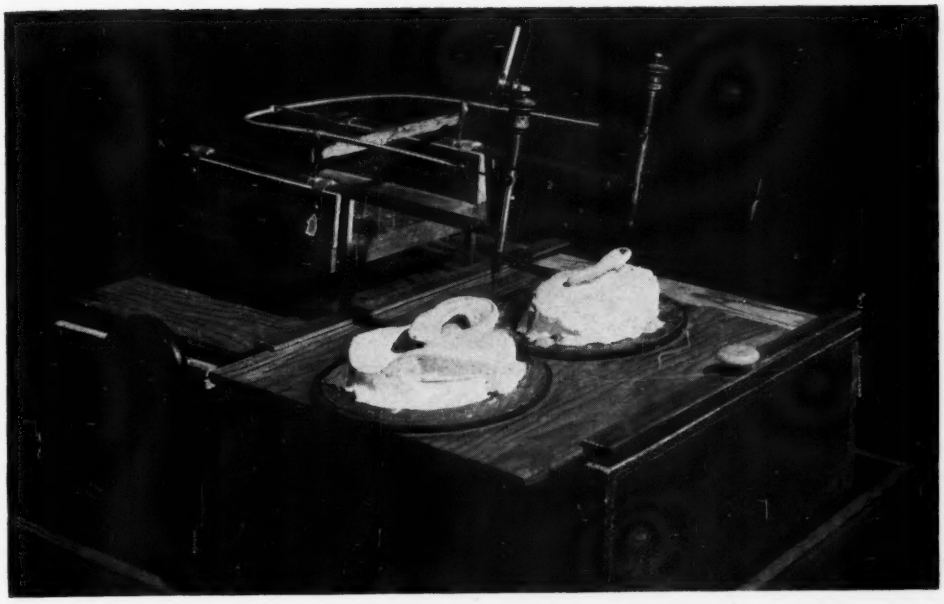

Fig. 2.

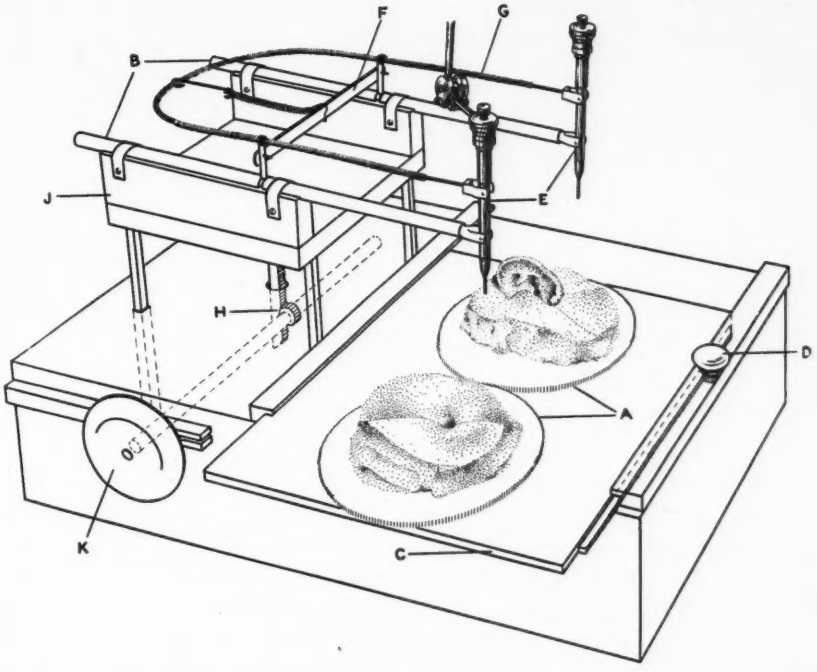

Fig. 3.

Two gears of the proper diameter form the outer surface of the two revolving tables (*A*). These gears are pivoted in the center and were made to mesh, and, as the one turns to the right, the other will turn to the left. The vertical lift of the control lever assembly table is made possible by a rack and pinion gear arrangement (*H*) attached to the base of the lever assembly table (*J*) and is controlled by a hand wheel (*K*). The lever assembly table is maintained in position by a square rod and tube arrangement in each corner of the lever assembly table. A combination of movements of the various moving parts will account for most of the contours necessary in a facial prosthesis.

SUMMARY

1. The third dimensional pantograph will give accurate measurements which will be applied in reverse.
2. It can be made to give measurements in any given ratio.
3. It will give vertical as well as horizontal measurements.
4. It will give angular measurements into undercut areas.

It was intended that this instrument would be used as a guide only, but it is so arranged that the hand piece can be connected to the engine arm and used as a router.

35 Lopez Ave.
San Francisco 16, Calif.

FACTORS INVOLVED IN MAXILLARY IMPLANT DENTURES

JOHN P. KNOWLTON, D.D.S.

Seattle, Wash.

IT IS NOT UNCOMMON to see an artificial denture wearer, who has flat, depressed, or knife-edge mandibular ridges, wage a continual battle with lower soft-tissue-borne dentures. We tend to forget that the factors influencing changes in the lower jaws of these patients are at work creating changes in their upper jaws as well. Normally, these conditions are tolerated better by a patient with an upper soft-tissue-borne denture because we are able to employ coverage of the palate, a post dam, and a border seal. Due to these aids, we can give the patient with poor ridges varying degrees of stability and retention, as well as a certain amount of function[1, 2] with an upper soft-tissue-borne denture. There are patients, however, for whom the only satisfactory prosthesis is an upper implant.

In this article, a discussion of full upper implants will be considered to include a description of conditions which influence their well-being, and ways of avoiding the pitfalls in construction of the implant casting and the superstructure.

We all realize that stability and retention play paramount roles in the construction of full soft-tissue-borne dentures. We have set about to try to alleviate the plight of debilitated denture patients who are wearing upper or lower soft-tissue-borne prostheses. Much has been done to rehabilitate these patients. As solutions to the problem as it concerns the upper denture, we find several methods employed which include magnetic dentures,[3] intraosseous implants,[4] the button technique,[5] and the implant denture method.[6, 7]

BONE

In the implant denture field, we are always obliged to work with four essential materials: the osseous structure, the metal casting, the periosteum, and the mucous membrane. The osseous structure consists of two types: (1) the cancellous or spongy bone, and (2) the cortical or compact bone. The only difference existing between the two lies in the degree of porosity.[8] Cortical and cancellous bone are present on the alveolar process, but the amount of compact bone varies in different areas. In the upper arch, "it is generally thinner on the labial or buccal than on the lingual surfaces,"[9] and undoubtedly this accounts for the types of atrophic changes that occur in the alveolar processes.

These changes, which appear in both the mandible and maxilla, affect the construction of the superstructure and the metal casting. When there are atrophic changes occurring in the osseous structure, in edentulous patients, they occur both in size and form.[10] They have been placed in the following categories: (1) hypoostosis, (2) osteodystrophia fibrosa, and (3) hyperostosis.[11]

Read before the American Academy of Implant Dentures, Chicago, Ill., Feb. 7, 1954.
Received for publication June 5, 1954.

Hypo-ostosis of the stomatic cavity is complete loss of the alveolar processes, with the soft tissue resorbing with the bone, and presents intraorally on the mandible, the mylohyoid, external oblique ridges and the genial tubercules, with a flat or depressed appearance of the previous alveolar process. In extreme cases, there is also a complete exposure of the mandibular canal. Resorption occurs in the maxillary arch just as it does in the mandibular arch. An obliteration of the alveolar process follows, leaving the palatal vault and the process on the same plane.

Osteodystrophia fibrosa is that condition in which resorption of the osseous structure occurs. The soft tissue, however, does not follow the bone, but remains, becomes hypertrophied, and interferes with the position of normally functioning dentures.

Hyperostosis is an atrophic condition resulting in the resorption of the buccal and labial plates of the lower arch, and presents high, sharp, knife-edge ridges. But in the upper arch the condition results in resorption of the external or buccal plate with the lingual or internal plate retaining its shape and size, with resorption taking place on the crest of the ridge due to pressure.

The alveolar bone is highly sensitive to most systemic conditions.[12] Because of this, I suggest that a complete report of the physical condition of the patient, including the metabolic conditions, be obtained from a qualified internist. We should ask ourselves: "Why did this patient first lose his natural teeth?" "Will the atrophic changes presented in this mouth continue?" "Can we control, or eliminate entirely, these existing conditions?" There are too many factors concerning the atrophic changes which may be a result of a deficient diet, an endocrine dysfunction, or a poor absorption of food to be discussed here, but these elements are important, and if any is found, proper treatment should follow directly prior to the performance of any implant work.

It has been found that the regions most subject to resorption in the upper arch are the molar and incisor regions of the crest of the alveolar ridge, except in the senile patients where resorption is general.[13-17] It would seem then that these areas are vulnerable to resorption under almost any type of load. More pressure is exerted with implant dentures than with soft-tissue-borne dentures,[18] and if the pressures from an implant were directed to these molar and incisor regions of the alveolar crest, there would be a definite loss of bone followed by failure of the implant restoration. Therefore, these areas must be avoided in the design of the implant casting. The casting should be designed so that the masticatory load is directed to the thicker cortical bone, since this is one of the hardest tissues in the body and can withstand tremendous pressure. It should be noted that cortical bone can withstand 18,000 to 24,000 psi in compression; 13,200 to 17,700 psi in tension; and 7,150 to 11,800 psi in sheer.[19] The findings of Yurkstas and Curby[20] show that the maximum average pressure used in the mastication of most foods is 26.4 pounds. We can, therefore, conclude that the tabular bones of the palate and the malar process of the maxilla would be the ideal foundations to receive and distribute these loads.

ENGINEERING AND IMPLANTS

Several points in relation to these two integrated fields should be established. In implant denture construction, not only the biologic but the mechanical aspects should be considered. In the field of engineering, before construction is begun, certain materials are selected to withstand the stresses and strains to be placed upon them. These materials must have what engineers call a "safety factor."[21] In dentistry, and particularly in implant work, we do not have a very wide selection of materials from which to choose, but as dentists we are obliged to regard this "safety factor." This factor is determined by engineers as 10 for structures and machines which are subject to shock loads or other unfavorable or unpredicted conditions. This number 10 is obtained by dividing the Ultimate Stress by the Actual Stress as represented by the formula US/AS=S. To achieve the factor of 10 or more in implant work, our casting must be placed on structures resistive enough to withstand the loads to which they will be subjected.

THE METAL CASTING

Vitallium, the metal used in this work, has been established by Venable and Stuck[22] as the ideal metal for implants because of its biologic compatibility with organic tissue. Physically, the ultimate tensile strength of Vitallium is 102,500 psi, and the modulus of elasticity is 31,200,000 psi.*

The casting should be designed to be rigid enough to decrease the modulus of elasticity, so the stresses exerted upon it can be carried uniformly throughout the entire osseous structure. In other words, it should act as a unit to resist the increased muscle power which the patient gained when he was changed from an edentulous state to an implant state.[23] If the casting is not designed correctly, forces will be exerted in the abutment areas only, and bone loss will occur with a subsequent loss of soft tissue, which in turn can cause exposure of the metal casting around the abutments.

Loechler[23] and Lew[24] have shown that the mucous membrane around the abutments will remain intact if the bone underlying the implant is maintained and if pressure on the mucosa from the superstructure is avoided.

RATIONALE OF DESIGN

Certain anatomic truths have been established which we should make use of when constructing upper implants.

1. The apices of the maxillary molar roots are located in the malar processes of the maxillary bones. According to Block,[25] the buccal roots of the maxillary first molar teeth are 13.2 mm. in length.
2. The base of the malar bone is compact and very resistive to compressive forces.

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*A portion of the report submitted by the New York Testing Laboratories of New York City.

3. The maxilla, more than any other bone, in the incisor and molar regions is subject to breakdown in local and/or systemic conditions.
4. The upper arch is more changeable than the lower arch.
5. The bones of the palate are resistive to changes.
6. Normally, thin soft tissues are present on the buccal surfaces of the maxilla.

All of these factors must be considered prior to the construction of an upper implant. A thorough knowledge of anatomy, physiology, and surgical procedures is needed so that no undue trauma is produced. Advanced treatment planning should assure an osseous impression which will include the palatal bones, the palatine processes of the maxilla, the entire prepared residual ridge, as well as the bases of the malar processes of the maxilla and the base of the anterior nasal spine. If the cast includes these structures, and if the casting is made accurately to fit this cast and to cover the correct structures, the greatest compressive load can be tolerated without danger of bone loss.

The design in current use is based primarily on Lew's technique,[7] as augmented by Block.[26] To ensure good design, good impressions are mandatory. It matters little which impression material is used as long as the operator is well versed in its properties. The alginates have performed well for me in recording the shape of bone surfaces with accuracy and detail of undercuts without distortion.

After the indicated bone surfaces have been exposed, and an accurate impression is obtained, design of the casting is undertaken. Complete coverage of the palate is necessary to assure a rigid casting. Few struts should go over the ridge. They should be preferably only in the abutment regions, if the case permits, in order to keep the bone from resorbing due to pressure. The casting should be carried high on the buccal surfaces to the base of the malar processes. It should approach, as near as possible, the length of the roots of the patient's former natural teeth. In the anterior region, the casting should contain the anterior arch, and should rest on the base of the anterior nasal spine to resist the forces of incision. This is illustrated by DeVan who said, "It has been my observation that the less artificial dentures are used for food comminution, the greater chance there is for bone preservation."[11]

Design is an important phase in constructing the upper casting. If the restoration is designed to re-establish the carrying of forces to the same areas occupied by the natural teeth, the resorptive process will be arrested. Just as the length and diameter of the roots of the molar are developed to support and resist forces applied against the tooth, so must the implant casting be designed to withstand forces that will tend to displace it, and to destroy the bone beneath it. Equally important is the angle at which the incisal and occlusal surfaces of the artificial teeth are placed in respect to the denture bases. Improper lines of force must be avoided, otherwise, the "forces directed along the lines of least resistance cause trauma; interfere with the capillary circulation resulting in lowered resistance in the traumatized area, and infections set in by way of the circulation. During

this period of low resistance, the osteoclasts are stimulated and cause destruction of the bone."[27]

During mastication, stresses are of three types: (1) vertical, (2) horizontal, or (3) a combination of both. Horizontal stress is more dangerous because of the torque it induces. This type of stress, in turn, causes pressure on the buccal bone surfaces with a subsequent loss of this bone.

The abutments and superstructure should be designed so as to create a stimulating, rather than a traumatic, effect. By this we mean that both casting and superstructure should be placed in such a manner that in lateral excursions, the occlusal forces will be carried in a direct line to the base of the malar bone, allowing this bone to receive the brunt of pressures exerted.

SUPERSTRUCTURE

There are many procedures used for the completion of the upper superstructure. The end results, however, should be the same: to finish the superstructure on the tissue side so that no pressure is exerted upon mucous membrane which might cause sloughing or destruction of this tissue. The teeth should be aligned in relation to the ridge as they are in the construction of soft-tissue-borne dentures. The location of the abutments has an important bearing on the finished superstructure. Extreme care should be exercised in placing these abutments in the proper relation to the alveolar process. The lines of force should be directed from the mandibular teeth through the maxillary superstructure to the osseous structure. The casting, although acting as a unit, has a tendency to rotate around a fulcrum on the working side. This action creates areas of tension and pressure which are produced by torque against the mucous membrane and the bone. This torque should be reduced, as much as possible, by the use of a cross, or end-to-end tooth relation, and by the use of flat plane plastic teeth. These modifications will tend to change horizontal forces to vertical forces.[28] Since destruction of the buccal plate of bone on the maxilla occurs quickly when horizontal stress is applied to it,[29] the implant casting design and the abutment-superstructure should be co-ordinated correctly to prevent this deterioration.

Any accepted denture technique can be used in the tooth arrangement for the superstructure. During the procedure, we use articulators, and it is admitted that even the finest of these has faults which can be exaggerated by the human element. These errors can prove suicidal in implant work, for we deal with living tissue and a solid bone foundation. The slightest discrepancy in occlusion can cause trauma to the bone and an eventual loss of it. To reduce the errors caused by the human element as much as possible, the patient is asked to grind in his superstructure into his own balanced occlusion by means of an abrasive paste. This procedure is carried out immediately following the placement of the superstructure. There is a follow-up appointment six weeks later, and periodic checkups thereafter, similar to the program followed for patients with natural dentitions.

SUMMARY

1. There is a place for the full upper implant denture.

2. Local and systemic factors should be determined prior to starting any implant work. This means that the medical picture can be as important as the dental one.

3. Basic engineering principles should be applied to implant denture construction, as well as a knowledge of the anatomic structures, and their functions as they apply.

4. Each phase of implant work should be viewed in light of the whole.

5. Periodic checkup appointments for implant denture patients should be made the same as for patients with natural dentitions.

CONCLUSION

Both the surgeon and prosthodontist engaged in implant denture work should realize the extent of their responsibilities and should cooperate closely in maintaining the health of patients with implants. These patients, like others, are susceptible to local and systemic changes. The functions of these doctors should be carried out carefully to ensure not only the well-being of their patients, but the success of the orthopedic appliance as well. Each step in the implant procedure should be viewed from the physiologic, biologic, surgical, and mechanical aspects. For these reasons, this work should be carefully planned, competently executed, and tempered with understanding and skill. Without these thoughts and purposes, our goals and our restorations alike, will be failures.

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947 Medical Dental Bldg.
Seattle 1, Wash.

TO CALCULATE THE "EFFECTIVE APERTURE" FOR DENTAL PHOTOGRAPHY BY MEANS OF THE WESTON MASTER II EXPOSURE METER

CHARLES SCHROETER*

School of Dentistry, University of Washington, Seattle, Wash.

THE meter reading is taken in the usual manner, with the exposure read at the desired "f" stop. For example, at a meter reading of 50 and Weston speed of 8, the reading is ½ second at f/16. This is not the proper exposure reading if the camera bellows is considerably extended.

To calculate the effective aperture with the Weston meter, the focal length of the lens, in inches, is read from the numbers of the f/ stop scale and this number is adjusted to the desired exposure time, on the time scale. For example, when a 4 inch focal length lens is used, the number 4 on the f/ stop scale is adjusted to ½ second on the time scale. The exposure time at f/16 can now be read on the time scale opposite the number indicating the bellows extension in inches, which must be measured. In the example given, with a 5 inch bellows extension, the reading is 4/5 second, which means the exposure time is 4/5 second at f/16.

After the meter is readjusted to 4/5 second at f/16, the time and f/ stop values can be read in the usual manner, and thus, at f/18 the exposure time is 1 second; at f/25 it is 2 seconds; at f/12.7 it is ½ second, and at f/8 it is 1/5 second.

Presented as a table clinic at the meeting of the Pacific Coast Society of Prosthodontists in Seattle, May 30, 1954.

Received for publication May 30, 1954.

*Director of Dental Photography, Instructor of Oral Anatomy.

ESSAY CONTEST

sponsored by

THE AMERICAN DENTURE SOCIETY

PRIZES WILL BE AWARDED to the two senior dental students who submit the best essays on prosthetic dentistry in the third annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students in the dental colleges of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college first conduct its own essay contest to determine the two best essays submitted by members of its senior class.)
3. All essays submitted in the contest shall be accompanied by a letter from the professor of prosthetic dentistry and/or the Dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
4. Essays must be postmarked on or before July 15, 1955 in order to receive consideration.*
5. Essays are to be on some phase of prosthetic dentistry and limited to a maximum of 2,500 words.
6. Essays must be worthy of publication in the Journal of Prosthetic Dentistry to qualify for a prize.
7. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. No carbon copies or essays on onion skin paper will be considered. Paragraphs must be indicated clearly by indentations and generous margins must be allowed on each page.
8. Illustrations must conform to the standards of the Journal of Prosthetic Dentistry if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the Figure number and the legend typed on the paper beneath the illustration.
9. References must conform to the style used in the Journal of Prosthetic Dentistry.

*Beginning with the 1955-1956 contest the closing date will be March 1, 1956. It is recommended that students start preparing their essays by the middle of their junior year and complete them by the middle of their senior year.

10. Essays are to become the property of The American Denture Society and none will be returned.
11. The judges of the contest are members of a special committee of The American Denture Society. The decision of the judges is final.
12. Essays are to be clearly marked "Contest Essay" and sent, along with a letter from the professor of prosthetic dentistry or the Dean of the dental college indicating that this essay is an official entry from that that dental college, to:

Dr. Carl O. Boucher
Editor, Journal of Prosthetic Dentistry
College of Dentistry, Ohio State University
Columbus 10, Ohio.

For further information write to: Dr. Arthur L. Roberts, Secretary, American Denture Society, Aurora Main Building, 4 Main Street, Aurora, Illinois.

News and Notes

ANNOUNCEMENTS

The American Denture Society will meet Feb. 4 and 5, 1955, at the Congress Hotel, Chicago, Ill.

The American Academy of Restorative Dentistry will meet Feb. 5 and 6, 1955, at the Conrad Hilton Hotel, Chicago, Ill.

The School of Dentistry, University of Pennsylvania announces several postgraduate courses of interest to prosthodontists.

Complete Denture Prosthesis, M. M. DeVan, March 7 to 12, 1955.
Complete Denture Prosthesis, Victor Lucia, March 28 to April 2, 1955.
Clinical Application of the Principles of Crown and Bridge Service, Ernest B. Nuttall, April 11 to 16, 1955.

For further information, write to the Director, Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce St., Philadelphia 4, Pa.

The College of Dentistry, Ohio State University announces several postgraduate courses of interest to prosthodontists.

Partial Denture Prosthesis, Victor L. Steffel, February 21 to 25, 1955.
Crown and Bridge, Frank C. Starr, March 21 to 25, 1955.
Complete Denture Prosthesis, Carl O. Boucher, April 4 to 8, 1955.
Anatomy of the Head and Neck, Linden F. Edwards, June 6 to 10, 1955.

For further information write to Director, Postgraduate Courses, College of Dentistry, Ohio State University, Columbus 10, Ohio.

Tufts College Dental School announces several postgraduate courses of interest to prosthodontists.

DPG. 702—Immediate Upper and Partial Lower Denture Prosthesis, Irving R. Hardy and Staff, each Tuesday for six weeks from April 5 to May 17, 1955. Class suspended April 19th.

DPG. 703—Full Denture Prosthesis, Irving R. Hardy, May 23 to June 3, 1955.

DPG. 706—Techniques for Relining Full Upper and Lower Dentures, A. Albert Yurkstas, February 9 and 10, 1955.

For further information, write to the Director, Graduate and Postgraduate Courses, Tufts College Dental School, 136 Harrison Ave., Boston, Mass.